MORPHOMETRICS, FISHERY AND BIOLOGY OF SOME FRESHWATER FOOD FISHES OF UTTAR PRADESH

THESIS SUBMITTED FOR THE DEGREE OF

Doctor of Philosophy

IN

ZOOLOGY

By

ABDUL RAHMAN ANSARI

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DIVISION OF ICHTHYOLOGY & FISHERIES

DEPARTMENT OF ZOOLOGY

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DEPARTMENT OF ZOOLOGY

ALIGARH MUSLIM UNIVERSITY
ALIGARH, (U. P.) India

Phone: University 285; Public 5646; Res. 4805, 4042

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1 ENTOMOLOGY
2 PARASITOLOGY
3 ICHTHYOLOGY & FISHERIES
4 AGRICULTURAL NEMATOLOGY
5 GENETICS

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CERTIFICATE

Certified that the research work entitled 'Morphometrics, fishery and biology of some freshwater food fishes of Uttar Pradesh' has been completed under my supervision by Mr. Jalil Rahman Ansari. The matter embodied here is original and was independently pursued by the candidate. It reports some interesting observations and is a distinct addition to the existing knowledge on the subject. Portion of work covered for M. Phil. requirements has been incorporated.

I permit the candidate to submit the thesis for the award of the degree of Doctor of Philosophy in Zoology (Fisheries) of the Aligarh Muslim University, Aligarh.

Saleem Mustafa

(Saleem Mustafa)
Ph.D.,
Lecturer.

DEDICATED TO

My father Late Sheikh Karimullah and elder father Late Mohd. Khalil. The later who expired about 15 years ago at Singapore, was very keen in my higher education. The present academic achievement partially fulfils his earnest desire.

C O N T E N T S

A C K N O W L E D G E M E N T S

The author expresses his gratitude to Dr. Saleem Mustafa for supervising the research work; to Professor Nawab Hasan Khan, Chairman of the Department, for providing laboratory facilities; to Professor Athar Husain Siddiqui and Dr. A.K. Jafri for encouragements.

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My thanks should also go my colleagues, especially Mr. Iqbal Ahmad Khan of Fisheries Research Laboratory for cooperation.

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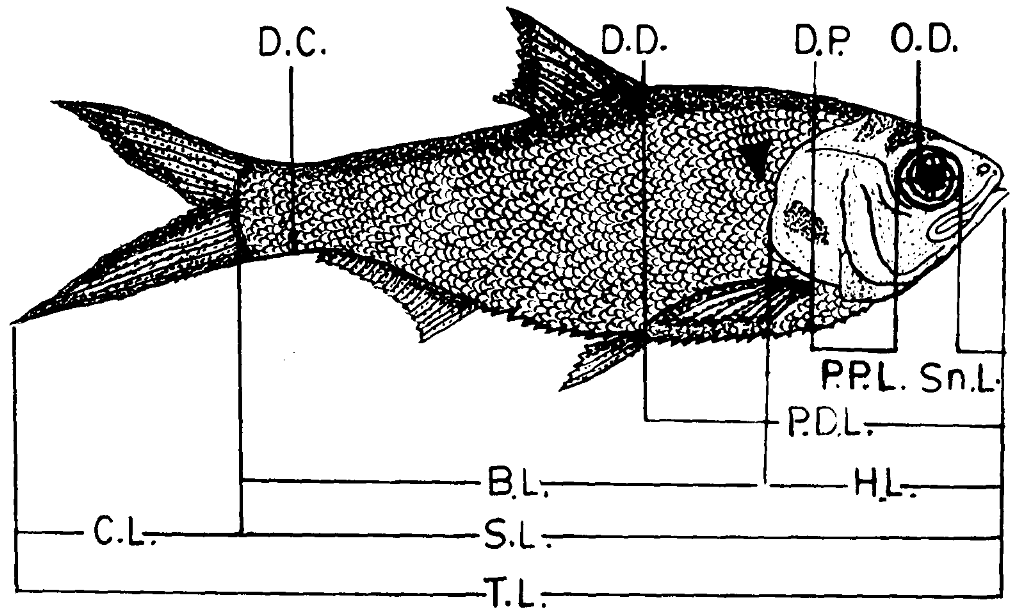
Finally, I wish to place on record my heartfelt thanks to my wife for having taken the full responsibility of children and bearing the domestic strain single handedly during the tenure of my work at Aligarh.

(ABDUL RAHMAN ANSARI)



GUDUSIA CHAPRA (HAM.)

PLATE 1.

GENERAL INTRODUCTION

A knowledge of the biology and fishery of commercially important fishes is of paramount importance in their rational management. Their monomass potential must be assessed and exploited. Although attention has been centered on fish as a source of cheap and quality protein but a compaign to popularize fish culture or development of commercial fisheries in many impounded water bodies such as dams and reservoirs is still a non-starter. Realizing the need of the hour a concerted effort was made on two reservoirs, Baigul and Nanaksagar, situated in district Nainital of Uttar Pradesh, to present information on limnological characteristics and magnitude of commercial fisheries, besides providing data on morphometric, meristic and various aspects of the biology of a teleost Gudusia chapra (Ham.), which forms the major part of the total fish catch.

A survey of literature reveals that little attention has been given to G. chapra. Jhingran (1972) gave a brief account of its diet composition and Chondar (1973,1977) presented data on length-weight relationship and fecundity. However, the specimens examined by these investigators were obtained from other environments, impressing upon the need to carry out detailed investigations on biology and bionomics of G. chapra. The work embodied in this thesis fills this vaccum. Reservoir limnologists and fisheries scientists are furnished with extensive data to base their planning for future work on Baigul and Nanaksagar impoundments

Systematic position of *Gudusia chapra* (Ham.)

Gudusia chapra was first described by Hamilton (1822) as *Clupanodon chapra*. Afterwards, Day (1878, 1889) gave the name *Clupea chapra*. Shaw & Shebbeare (1937) as *Gadusia chapra*. Latter on, Regan (1917), Fowler (1941), Misra (1947, 1952) and Srivastava (1968) named this species as *Gudusia chapra*. The systematic position is based on the scheme of classification suggested by Berg (1947).

Phylum	:	Chordata
Sub-phylum	:	Vertebrata (Craniata)
Super-class	:	Gnathostomata
Series	:	Pisces
Class	:	Teleostomi
Sub-class	:	Actinopterygii
Order	:	Clupeiformes
Sub-order	:	Clupeoidei
Super-family	:	Clupeoidae
Family	:	Clupeidae
Sub-family	:	Clupeini
Genus	:	*Gudusia*
Species	:	*chapra*

Common names:- 'Suhia', 'Suiya', 'Coori'.

Salient features:

Body oblong, well compressed, ventral profile more convex than the dorsal one. Mouth oblique and terminal. Beak-like lower jaw fits tightly into upper jaw when mouth is closed. Maxilla straight, narrow and extends almost to the middle of the orbit. Supplemental bone attached to maxilla. Eyes provided with broad adipose lids. The ratio of snout and head length varies from 4.8 to 5.1. Subopercle large and tapering posteriorly. Teeth, barbles and adipose fin absent. Abdomen keeled and serrated. A variable number of abdominal scales along the midventral region modified into scutes. Dorsal fin originates slightly before the origin of ventral fin. Dorsal fin height maximum anteriorly. Pectoral fin reaching the ventral. Anal highest in front. Caudal fin deeply forked, lower lobe distinctly larger than the upper one. Marginal rays of caudal fin higher than the central one.

Scales smooth, cycloid and placed in horizontal rows more closely set over the abdomen; the lateral line scales 80-110, pre-ventral scutes 15-18, post-ventral scutes 8-11. Post ventral scutes higher than pre ventrals. Body bright silvery white, except on the back which takes a greenish grey tinge. Margin of caudal fin blackish. A dark spot present or absent on the shoulder above the lateral line, behind the operculum.

The present studies enabled the revision of the fin formula:

D. 14-16(3/11-13); P. 12-13; V. 7-8; A. 21-24(2/19-22); C. 16-18; Ll. 80-110; Ltr. 32-35.

The maximum size of the fish recorded by the author is 215 mm.

<u>Geographical distribution</u>:

G. gharua is a freshwater fish inhabiting rivers, lakes, tanks and reservoirs throughout Northern India and is also distributed in the South as far as the Krishna and Godavary rivers. It has not been reported from the freshwaters of Western Malabar and Eastern Madras.

G. gharua constitutes a substantial part of catch from Baigul and Nanaksagar reservoirs. Its market value is lower compared to major carps, but the quantity utilized is considerably more. A small part of the catch is consumed by local population while the rest is transported to West Bengal where it is in great demand. The fish is consumed locally in fresh condition and marketed after salting and sun drying.

PART I

TOPOGRAPHY AND PHYSICO-CHEMICAL CONDITIONS OF BAIGUL AND NANAKSAGAR RESERVOIRS

INTRODUCTION

A reservoir is a large expense of impounded water artificially created for irrigation, civil supply, power generation, glood control, commercial fisheries and recreational fishing. About 3 million hectares of water area is available in reservoirs but the reservoir fisheries in India have always been neglected in the past. Exploitation of these lacustrine environments for fisheries was never even considered at the time when impoundments of reverine resources were planned. Physical and chemical characteristics of a river are so much different from a resorvoir that only a selected variety of animals prefer remaining in the still water. A balanced assessment of the influence of riverine conditions on the life of the fishes has been remarkably presented by Nikolsky (1963). In his own words ...... "by partitioning off the rivers with dams and creating reservoirs, man on the one hand destroys the conditions for the reproduction of migratory fishes, by barring them from access to their spawning grounds, sometimes actually destroying the spawning grounds, because they are under a head of water and often become silted up. On the other hand, the reservoirs frequently provide more favourable conditions for the life of limnophil fishes than there were in the former streams, and these fishes increase in abundance. At the same time the conditions for rheophil fishes often deteriorate, and these are forced to enter the tributaries. Finally, the formation of a reservoir greatly affects the flow of water in the rivers, which changes the conditions for the reproduction of semimigratory fishes. The area of the flood-meadows in which the fish spawn is reduced, the duration of the flood period is changed, and this is naturally reflected in the reproduction of these fishes. The total volume of the flow is also changed, in connection with which there may be a fall in the level of land-locked seas and lakes, while there may be an increase in the salinity of the estuarine parts of seas and salt lakes into which regulated waters discharge. The biological stock also changes. A significant part of the biogenic elements accumulates in the reservoirs and is no longer carried out by the rivers into the sea, which causes the food supply of the fishes in these estuarine regions to be greatly reduced. Naturally the reduction of the food supply affects the growth rate, fat content, fecundity, and other properties of the commercial fishes ....".

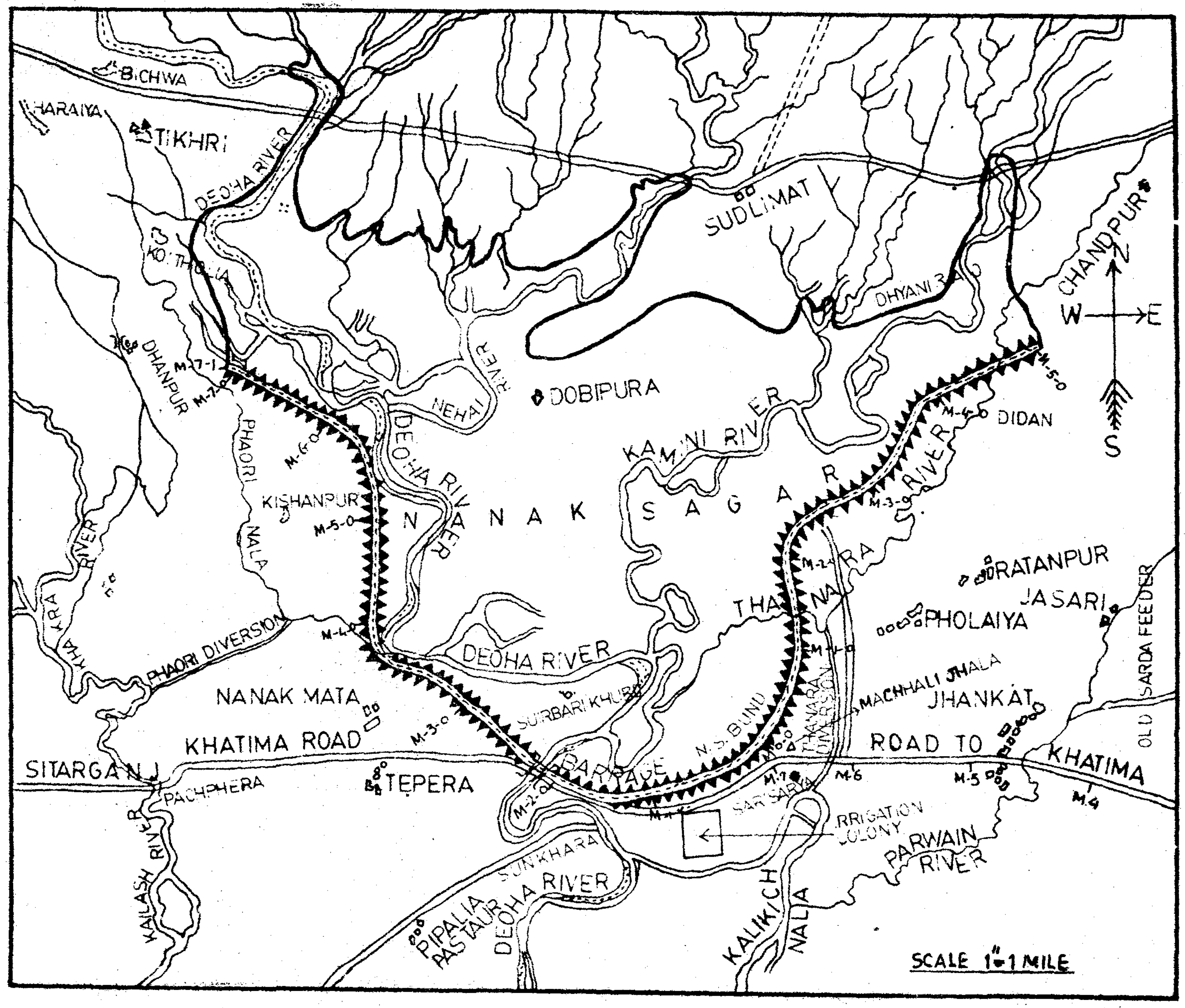
In view of the above reasoning it seems absolutely essential that hydrobiological surveys of the rivers likely to be impounded be carried out and special emphasis given to ichthyofauna with the aim of determining the tolerance levels, limitations and above all survival and propagation under reservoir conditions. The information so gained merits consideration at the planning stage if at all the populations of fishes and shell fishes are to be properly managed and rationally exploited.

Now that a large number of huge reservoirs already constructed the planning and modification stage a thing of the past, one cannot but reconcile with their existence on howse-ever faulty layout from fisheries view point, and yet find out efficient and effective means of the conservation of the resources of water and its biomass. Even from these reservoirs annual fish catch amounts to 25,000 tonnes if average production is assumed to be around 8-10 kg/hectare. But since certain better managed reservoirs are yielding more than 40 kg/hectare, the potential of total Indian reservoirs can safely be put at well above 125,000 tonnes.

In India where floods and draught both play havoc, more reservoirs will be constructed to cope with the natural calamities. During the wet season when the rivers touch or cross the danger marks and overflow, the surplus water can be stored in the reservoirs to control flooding and inundation, whereas during the dry spells the impounded water can be diverted for the irrigation. At least for the future reservoirs and those still in planning stage, lack of provision for commercial fisheries or recreational fishing will find no excuse.

A survey of literature reveals that despite considerable studies on the ecology of lakes and ponds, even including those of little fisheries importance, information on reservoirs is scantly. Fewer reports which are available to date pertain to tanks and reservoirs of peninsular (South) India, but from the

Fig. 1. Topography of Baigul reservoir.



BICHWA
HARAIYA
TIKHRI
DEOHA RIVER
KOTHOA
DHANPUR
SUDLIMAT
CHANDPUR
DHYANI RAO
N
W
E
S
DOBIPURA
NEHAI RIVER
DEOHA RIVER
KAMINI RIVER
NANAK SAGAR
DIDAN
PHAORI NALA
KISHANPUR
KHAKRA RIVER
PHAORI DIVERSION
NANAK MATA
DEOHA RIVER
SURBARI KHURD
THANARA RIVER
THANARA DIVERSION
N.S. BUND
BARRAGE
RATANPUR
JASARI
PHOLAIYA
MACHHALI JHALA
JHANKAT
OLD SARDA FEEDER
KHATIMA ROAD
ROAD TO KHATIMA
SITARGANJ
PACHPHERA
TEPERA
SARSARIA
IRRIGATION COLONY
PARWAIN RIVER
KAILASH RIVER
SUNKHARA
DEOHA RIVER
PIPALIA
PASTAUR
KALIKICH NALA
SCALE 1"=1 MILE

Undergrowth of grasses among those plants is a common feature at the slope of the basin. The basin of the reservoir is not smooth due to localized accumulation of erosion material. A layer of yellowish muddy silt and gravel covers the bottom. The submerged area is characterized by rooted aquatic vegetation, mostly unwanted weeds. Water is quite clear and maintains a pH 7-8.2. However, water close to the banks becomes turbid in monsoon season. The direction of water flow in North-South. Almost all freshwater fishes represented in Ganges river system are found in Baigul. Population of Shrimps, bivalves and gastropods also flourish. The average production of fishes and shell fishes combined is 47.5 kg/hectare on full storage level.

Nanaksagar reservoir:

Nanaksagar reservoir (Fig. 2) is situated on the foot of Kumaon hills at Sitarganj - Khatema road, 4 km away from Nanak Mata, a sacred place of Sikh community in Nainital District. Its geographical location is Lat. 28° 58' 55" N, Long. 79° 50' 12" E. The bowl shaped earthen dam with 19.3 km length constructed by the State Government was commissioned in June, 1962. Water of the Deoha, Thanare, Kamina rivers and small hill streams is discharged and impounded in Nanaksagar. The reservoir has an area of 18 square miles, 1.7 lakh acres of full water storage capacity. The maximum water spread on high flood level is of the order of 708.5 ft. whereas minimum/dead storage level 680 ft.

Spillway capacity being 50,000 Cusecs. The bottom of the reservoir is largely smooth and has yellowish muddy silt gravel and considerable quantity of detritus. Direction of water flow is the same as in Baigul.

MATERIALS AND METHODS

Information on topography, water levels of the reservoirs and rainfall was obtained from Civil Construction Division, Bareilly. Data pertaining to weather, wind direction and other features were based on personal observations. Atmospheric and water temperatures were measured by sensitive centrigrade thermometer. Surface water samples were collected from three different spots: place of river discharge, mouth of barrage and middle zone, over a period of 15 months (October 1977 - December 1978) in case of Baigul, and 12 months (January 1978 - December 1978) in case of Nanaksagar. Sampling was carried out in the last week of each month. pH was recorded by the help of pH-indicator papers (BDH). Methodology for the analyses of dissolved oxygen, free carbondioxide, carbonates, bicarbonate and chloride was the same as suggested by American Public Health Association (1960). The transparency was measured by standard secchi disc.

OBSERVATIONS

Seasonal data pertaining to physical and chemical factors for the period 1977-78 have been tabulated (Table I) and incorporated in Figs. 3, 4.

The rainfall was 6, 3, 88, 41, 20, 100, 151, 178 and 136 mm in December, January, February, March, April, June, July, August and September, respectively in Baigul locality. In Nanaksagar during the months of February, March, April, June, July, August and September it was registered as 103, 53, 42, 507, 525, 546, 205 mm respectively. The rainfall was heaviest in August. The winter-rainfall was affected by North-East and in the summer by the South-West monsoon.

Weather remained generally cloudy during June-September. The monsoon season was characterized by torrential rains. Occasional cloudy conditions also prevailed in January-March with poor radiations. Precipitation was low. In remaining months of the year weather was clear and sunny.

The atmospheric temperature at Baigul (11.5°C - 34°C) was a little lower than that at Nanaksagar (12.5 - 38°C). May was the warmest part of the year, while January the coldest one. Pattern of change in the water temperature was identical with that of the air. In Baigul it ranged from 14°C (January) to 33°C (May) compared to Nanaksagar where it fluctuated between 16°C - 35°C, with minimum and maximum temperatures in the same months.

Water level in Baigul reservoir fluctuated from 203.51 -

210.46 ft, whereas in Nanaksagar it was 679.75 - 698.15 ft. The maximum level was noted in August (Baigul) and September (Nanaksagar). The minimum level was recorded in May and June in Baigul and Nanaksagar, respectively.

Secchi disc measurements of Baigul were seen to vary from 230.7 cm (March to 24.4 cm (July - August). An increasing trend in transparency was noticed from October to March, and a decreasing one during April - August. In Nanaksagar maximum (244 cm) and minimum (60.6 cm) secchi disc readings were obtained in March and September, respectively. Declining order was discernible from April to September but onward i.e., from October all the way upto March, values maintained a steady increase.

Dissolved oxygen concentration in surface water of Baigul reservoir was recorded high in the months of December (10.5 ppm) and May (11.0 ppm) and low in August (6.5 ppm) and September (5.9 ppm). A gradually decreasing pattern was noticeable during June-September. However, in Nanaksagar the dissolved oxygen level fluctuated from 4.6 ppm (September) to 11.8 ppm (May). Values maintained a constant decrease from June to September.

Water was tested for free carbondioxide but it was found absent from the surface water of the two reservoirs during the study period. In Baigul: carbonate was present and varied from 13.6 ppm (April) to 8.0 ppm (December); bicarbonate changed between 80 ppm (August) and 96.8 ppm (December); total alkalinity value was maximum (106.6 ppm) in May and minimum (86.8 ppm) in September. In Nanaksagar: maximum and minimum values were 12.8 ppm (May) and 7.2 ppm (August) for carbonate; 97.0 ppm (May) and 86.6 ppm (September) for bicarbonate; 109.8 ppm (May) and 84.8 ppm (September) for total alkalinity. Evidently, the monthly trend of variation in carbonate, bicarbonate and alkalinity was strikingly similar.

Chloride concentration of water was higher (19.8 ppm) in June and lowest (7.1 ppm) in August in the Baigul. In Nanaksagar the value was maximum (196.6 ppm) in the month of May and minimum (5.6 ppm) in August.

In Baigul pH fluctuated between 7.0 and 8.2. There was no definite monthly pattern of variation in pH value. Like that in Baigul, the pH in Nanaksagar water varied within narrow range (7.1 - 8.0).

D I S C U S S I O N

Fluctuations in water temperature are known to affect the inhabiting organisms directly as well as through alterations in the contents of dissolved gases, nutrient cycle and several biogenic processes (Hutchinson, 1957). Seasonal variations in the temperature of water in Baigul and Nanaksagar reservoirs were correlated with thermal conditions of the atmosphere. Intense heating of water during the sunny and dry weather in summer, especially in May, brings about a sharp rise in the water temperature. In addition to direct absorption of solar radiations, heat from the air is also transferred to the water.

In the absence of noticeable differential between air and water temperature, any marked thermal stratification, howsoever, shortlived, can only be thought of as a remote possibility. While Srinivasan (1965) and Rao & Govind (1964) rule out this phenomenon in Tungabhadra reservoir, other workers (Ganapati, 1955; Ganapati & Chacko, 1959; Saha et al., 1971) agree with the absence of permanent thermal stratification in tropical lakes and reservoirs, but hold that it occurs temporarily during day time and is broken up at night when the disparity between air and water temperatures gets minimized.

Penetration of light in an aquatic ecosystem depends upon a number of factors including intensive radiation, their angle of contact, latitude, amounts of dissolved or suspended materials (Welch, 1952; Ruttner, 1953; Hutchinson, 1957). Significant reduction in the water transparency during the monsoon season could be attributed to poor sunshine, inflow of silty and muddy water which increases the turbidity. Low turbidity and high light penetration during other parts of the year are associated with the luxuriant growth of rooted vegetation, particularly in case of Baigul.

Aquatic environments receive oxygen through direct absorption from atmosphere and photosynthetic activity of the resident flora wherein it is released as a byproduct. Temperature alters the dissolved oxygen level by changing the oxygen-holding capacity of water.

In Baigul and Nanaksagar reservoirs high concentration of dissolved oxygen in the premonsoon summer season can be linked with illumination even at greater depths and brisk photosynthetic activity of large populations of phytoplankton and macrovegetation. After decline in monsoon the dissolved oxygen content of water seemed to rise in winter, obviously due to low turbidity and hence high transparency, and reduction of oxygen uptake in the process of organismal respiration. In either reservoir oxygen level remains well above the minimum oxygen tolerance for fish which stands at 3 ppm according to Tarzwell (1957).

Free carbondioxide was never present in the surface water of Baigul and Nanaksagar reservoirs. Evidently, whatever carbondioxide is produced by the biota during the process of respiration is utilized in photosynthesis, or else it enters into combination with some substances. The persistence of carbonates and bicarbonates substantiates this view, as these represent the transformation products. The bicarbonate level is generally higher than that of carbonate, implying that larger amount of carbondioxide is utilized in the formation of the former and a relatively smaller quantity is available for the formation of later. Seasonal pattern of fluctuations in carbonate, bicarbonate and chloride in the two reservoirs seems related chiefly to the water level. Decline in water volume as a result of evaporation loss increases values of these substances and diversion of considerable quantity of water during monsoon dilutes them. This is in conformity with the views of Jana (1973). Regarding the carbonate and bicarbonate, the fluctuations are also caused by differences in their utilisation in photosynthesis. Relative magnitude of different factors can not, however, be ascertained from the collected data.

The pH maintained such an indefinite trend that it is difficult to pin point the basis of its fluctuations. In the past other workers have tried to link it with carbonate (George, 1961; Verma, 1967; Sreeniwasan, 1972) and phytoplankton blooming (Moitra & Bhattacharya, ~~1961~~; 1966; Jana, 1973).

It is important to point out that in Baigul and Nanak-sagar the medium with a pH varying from 7.0 - 8.2 is conducive to fish culture according to the pH - suitability scale described by Hora & Pillay (1962). The range of pH of cultivable water suggested by these authors is 7.0 - 8.0.

TABLE - I

Atmospheric conditions and physico-chemical properties of reservoirs.

Date	Weather	Rainfall (mm)	Water level (ft)	Transparency (cm)	Temperature (°C)			Dissolved oxygen (ppm)	Alkalinity (ppm)			Total alkalinity (ppm)	Chloride (ppm)	pH
					Air	Just above water	Water		CO_2	CO_3	HCO_3			
							B A I G U L							
26.10.77	Clear	Nil	205.79	80.4	24.0	25.0	25.0	8.0	Nil	8.4	86.5	94.9	7.8	7.3
26.11.77	"	Nil	206.35	90.5	15.0	16.0	20.0	9.6	Nil	8.8	93.5	102.3	8.8	7.5
26.12.77	"	6	206.66	135.0	12.5	13.5	16.0	10.5	"	8.0	96.0	104.0	10.5	7.2
31.1.78	"	3	205.95	166.5	11.5	12.5	14.0	8.7	"	8.6	86.8	95.4	9.3	7.4
27.2.78	Cloudy	38	206.14	201.6	17.5	16.5	18.5	8.0	"	9.2	87.0	96.2	13.0	7.5
29.3.78	"	41	206.35	230.7	20.0	19.0	21.5	7.3	"	11.3	86.6	97.9	15.2	7.7
29.4.1978	Clear	20	204.68	115.6	29.0	28.5	29.5	9.4	"	13.5	88.2	101.7	16.5	7.6
31.5.78	"	Nil	205.51	85.2	34.0	30.0	33.5	11.0	"	11.6	95.0	106.6	17.6	7.8
30.6.78	Cloudy & rainy	100	204.76	32.5	30.0	29.0	31.0	8.7	"	9.9	83.0	92.9	19.8	8.2
30.7.78	"	151	206.15	27.6	28.5	27.5	29.0	8.1	"	9.6	82.2	91.8	8.5	7.2
29.8.78	"	178	210.46	24.4	26.[illegible]	25.5	27.0	6.5	"	9.3	80.0	89.3	7.1	7.0
27.9.78	"	136	207.26	45.5	25.0	24.5	25.5	5.9	"	8.8	78.0	86.8	7.4	7.1
29.10.78	Clear	Nil	206.56	82.5	21.5	21.5	22.0	8.9	"	8.6	89.5	98.1	7.6	7.4
28.11.78	"	"	206.00	98.3	14.0	15.0	18.0	10.5	"	9.0	94.0	103.0	8.5	7.6
30.12.78	"	"	205.85	128.8	11.5	12.0	16.5	10.7	"	8.4	96.8	105.2	10.0	7.6
							N A N A K S A G A R							
30.1.78	Clear	Nil	691.76	135.6	12.5	12.0	16.0	8.0	Nil	8.4	85.8	94.2	12.4	7.2
28.2.78	Cloudy	103	689.60	284.5	18.5	18.5	21.5	7.2	"	8.9	83.8	92.6	12.0	7.3
29.3.78	"	33.	690.25	244.5	21.0	23.0	25.5	8.4	"	10.0	92.5	102.5	14.4	7.6
30.4.78	Clear	42	684.20	188.0	34.0	32.0	30.5	10.2	"	12.0	94.0	106.0	17.5	7.8
31.5.78	"	Nil	679.75	160.4	38.0	46.0	35.0	11.8	"	12.8	97.0	109.8	19.6	7.6
29.6.78	Cloudy & rainy	507	685.00	88.5	31.0	32.0	32.5	8.0	"	9.4	86.3	95.7	15.0	8.0
31.7.78	"	525	696.10	76.0	29.5	28.5	31.0	7.4	"	9.0	80.5	89.5	6.0	7.4
29.8.78	"	546	697.36	67.8	27.5	26.5	29.5	5.2	"	7.2	79.4	86.6	5.6	7.1
28.9.78	"	205	698.15	60.6	26.5	25.5	27.5	4.6	"	8.2	76.6	84.8	5.8	7.2
30.10.78	Clear	Nil	697.00	115.8	22.5	23.5	24.5	6.6	"	7.6	94.2	101.8	6.5	7.3
29.11.78	"	"	695.86	135.3	17.0	18.5	19.5	9.4	"	7.9	96.5	104.4	8.0	7.3
31.12.78	"	"	694.42	156.0	13.0	13.5	18.5	10.0	"	7.7	98.0	104.0	11.7	7.7

Fig. 3. Atmospheric conditions and physical factors
(o——o, Baigul; ●——●, Nanaksagar)

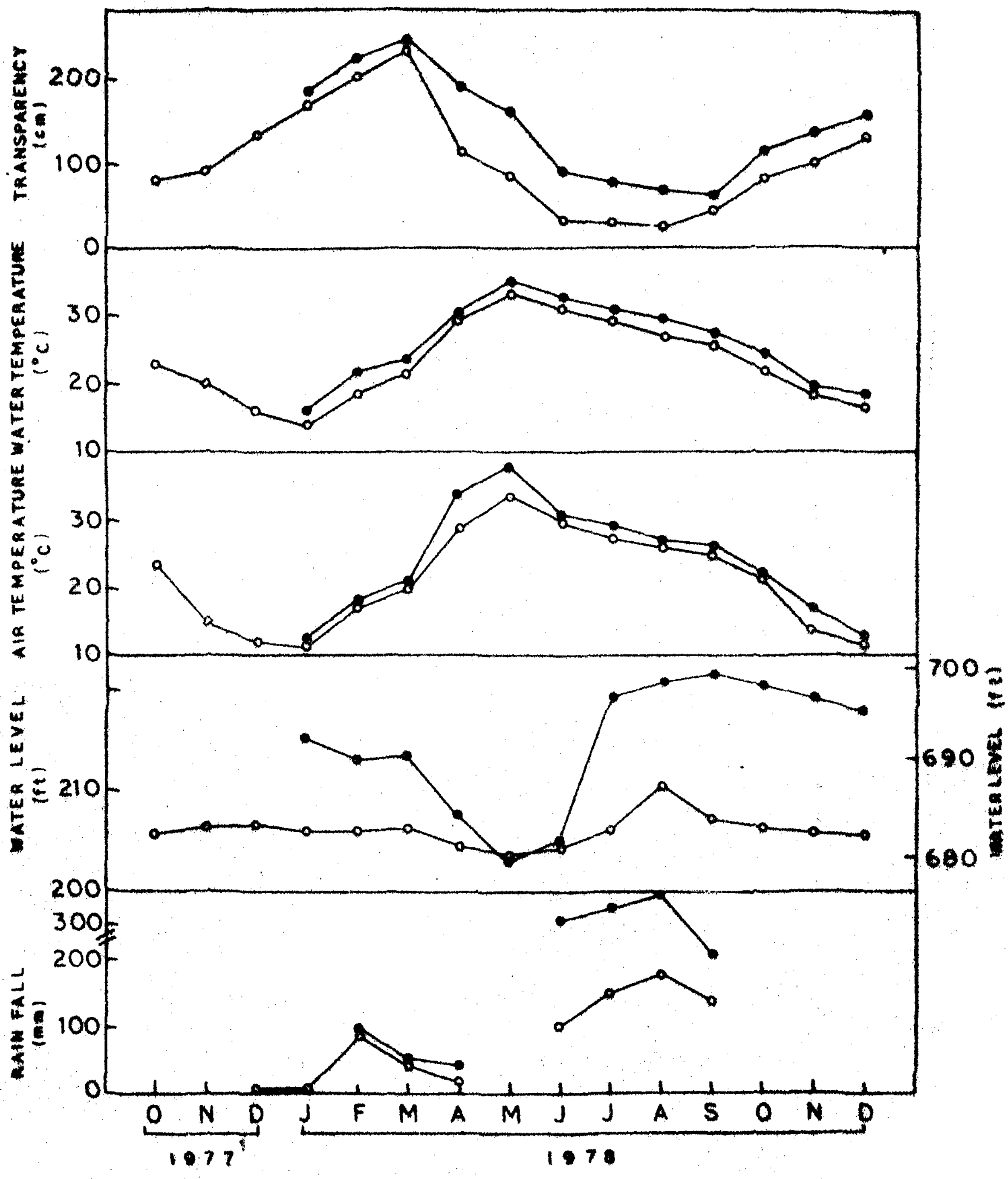
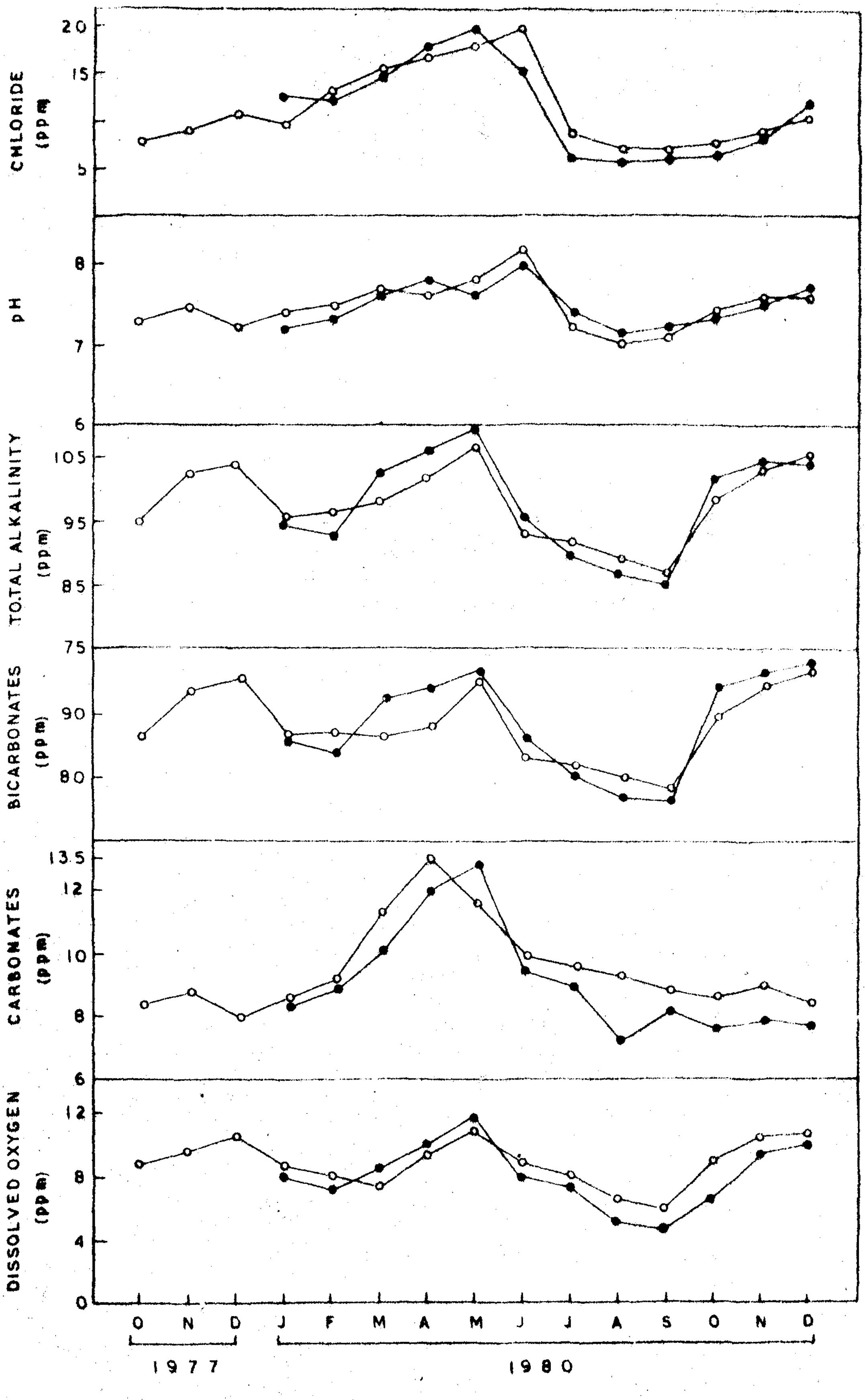

TRANSPARENCY (cm)
200
100
0
WATER TEMPERATURE (°C)
30
20
10
AIR TEMPERATURE (°C)
30
20
10
WATER LEVEL (ft)
210
200
WATER LEVEL (ft)
700
690
680
RAIN FALL (mm)
300
200
100
0
O N D J F M A M J J A S O N D
1977
1978

Fig. 4. Chemical properties of water (O———O, Baigul; ●———●, Nanaksagar).


CHLORIDE (ppm)
20
15
5
pH
8
7
6
TOTAL ALKALINITY (ppm)
105
95
85
75
BICARBONATES (ppm)
90
80
CARBONATES (ppm)
13.5
12
10
8
6
DISSOLVED OXYGEN (ppm)
12
8
4
0
O N D J F M A M J J A S O N D
1977
1980

PART II

MORPHOMETRIC AND MERISTIC STUDIES ON

GUDUSIA CHAPRA (HAM.)

I N T R O D U C T I O N

Morphometric and meristic studies on fishes are employed in systematics for identification and classification, as also in discriminating the races or sub-populations in the same or different water bodies. Several ichthyologists (Hile, 1937; Godsil, 1948; Schaefer, 1948; 1952; Schaefer & Walford, 1950; Marr, 1955; Royce, 1963; Fowler, 1970; Khan & Qadri, 1970) have provided morphometric data on many fish species and emphasized their utility in separation of stock or races in different environments. Ames *et al.* (1979) and Berg (1979) outlined important meristic characters and discussed factors responsible for numerical variations. Some other contributors in the field who have furnished information on Indian fish species are Pillay (1957), Gupta (1970), Srivastava & Tyagi (1979), Dwivedi & Rattan (1980) and Jayaram (1980). As far as the author is aware morphometric characters of *G. chapra* were studied only by Chondar (1974, 75) who suggested necessity of further exhaustive efforts because of the inadequacy of his data. Present work was, therefore, undertaken with a view to furnish comprehensive account of morphometric and meristic characters of *G. chapra* from Baigul and Nanaksagar reservoirs.

MATERIALS AND METHODS

Samples of G. chapra (total length 39-215 mm) numbering 130 and 140 were collected from Baigul and Nanaksagar reservoirs, respectively. For the various topographic measurements some of which are shown in Plate 1, the conventional scheme described by Blair et al. (1957) was followed.

Total length (TL): Distance from tip of the snout (when mouth is closed) to the longest ray of caudal fin, 'X'.

Standard length (SL): Distance from tip of snout (when mouth is closed) to the posterior edge of the last scale along the lateral line, 'Y_1'.

Head length (HL): Distance from tip of snout (when mouth is closed) to the posterior most margin of sub-opercle, 'Y_2'.

Body length (BL): Distance from the posterior margin of sub-opercle to the posterior edge of the last scale along the lateral line, 'Y_3'.

Pre-dorsal length (PDL): Distance from tip of snout (when mouth is closed) to the origin of the dorsal fin along its base, 'Y_4'.

Post-orbit to pectoral fin length (PPL): Distance from posterior margin of orbit to the origin of pectoral fin 'Y_5'.

Orbit diameter (OD): Distance between anterior and posterior margins of the orbit along the longitudinal plane, 'Y_6'.

Depth through pectoral fin base (DP): Depth of body along the plane of origin of pectoral fin, 'Y_7'.

Depth through dorsal fin base (DD): Depth of body at the point of origin of the dorsal fin, 'Y_8'.

Depth of the caudal peduncle (DC): Depth of deepest zone of the caudal peduncle, 'Y_9'.

Caudal length (CL): Distance from last lateral line scale to the tip of the lower lobe of caudal fin, 'Y_{10}'.

Snout length (SnL): Distance from tip of snout (when mouth is closed).to the margin of preorbital bone, 'Y_{11}'.

Scale count

A row of perforated scales along the lateral line (lateral line scales, Ll) were counted from the posterior margin of opercle to the base of caudal fin.

Number of lateral transverse scales (ltr) were counted from the anterior base of dorsal fin to the lateral line and from lateral line to the mid-ventral line.

Scute count

Total number of scutes: Number of scutes along the mid-ventral line from the ventral plane of head to the anal opening.

Pre-pelvic scutes: Number of anterior scutes upto the place of origin of pelvic fin.

Post pelvic scutes: Number of scutes from the posterior extremity of the base of pectoral fin upto the anal opening.

Fin ray count: The branched as well as unbranched rays of dorsal, pectoral, ventral (pelvic), anal and caudal fins were counted. For this purpose the fins were spread and help of needle and lens taken.

Relationships of various characters (Y_1 to Y_{11}) with the total length (X) were worked out by the following logarithmic regression equation:

$$\text{Log } Y = \text{Log } a + b \log X$$

Where log 'a' = intercept and 'b' = slope of the regression.

Methods followed for evaluation of log 'a' and 'b', correlation coefficient, co-variance, chi-square (X^2), 't' and for other statistical processing of data were the same as given by Mather (1964) and Snedecor & Cochran (1980).

Total length was considered as the standard parameter for reference, in the derivation of ratios of the various characters (Y_1 - Y_{11}). For obtaining indices of these characters, the measurements of the parameter were expressed as percentage of the total length of the fish.

RESULTS AND DISCUSSION

The relationships of various mentioned measures of the body with total length of G. chapra from Baigul and Nanaksagar have been presented in Table I and shown graphically (Fig. 1). The lograthmic relationships are linear. The significant correlation coefficients indicate that standard length, head length, body length, predorsal length, orbit diameter, body depth, through pectoral, dorsal and caudal fins, post orbital-pectoral fin distance, caudal length, snout length, respectively vary 0.98, 0.89, 0.96, 0.95, 0.85, 0.88, 0.97, 0.89, 0.96, 0.85, 0.81 times the total length in Baigul specimens and 0.80, 0.79 0.81, 0.77, 0.53, 0.80, 0.83, 0.76, 0.98, 0.76, 0.48 times the total length in Nanaksagar fish. Excepting for post orbit-pectoral fin distance total length, the exponents of all other relations were higher in fish from Baigul reservoir.

A detailed statistical analysis (Tables II-IV) revealed that intra-specific variations existing in the various characters of fish population of a sreservoir were not significant. Multi-racial composition of the population was, therefore, ruled out. The covariance data used for comparison, however, showed differenses between populations of the two reservoirs. This strengthens the possibility that G. chapra of Baigul and Nanaksagar belong to different stocks/races or subpopulations. Their allopatry is indeed a barrier to the intermingling and interbreeding. Fish stock of each reservoir is certainly inbred one.

Mean values and variability of various characters, their ratios and indices derived keeping the total length as the standard (reference) parameter are elaborated in Table V. The absence of marked difference implied that individual variations in the relative growth of the various body parts are within biologically permissible limits that serve to restrict the ontogenetically originated allomorphosis and heterogony. These factors manifest in acquisition of proportionate body dimension but at the same time can form basis of differentiating the stocks from different environments.

Variations in meristic characters (scales, scutes and fin rays) are clearly indicated (Tables VI-VII). But almost equal amount of variability within the population of the same habitat makes it difficult to conclude on racial differences in G. chapra exclusively on the basis of differences in the frequency of occurrence of these characters even if explicitly indicated.

Morphometric or meristic data for males and females were thoroughly processed statistically to find out the possible sex-linned differences but the lack of significant difference in any of the traits implied absence of sex dimorphism.

TABLE - I

Relationships of the various body measurements with the total body length of *O. shama*

Relationship	Baigul specimens*		Nanaksagar Specimens**	
	Regression equation	Correlation coefficient 'r'	Regression equation	Correlation coefficient 'r'
Standard length / TL	Log Y = −0.0696 + 0.9809 Log X	0.98 (P ∠ 0.001)	Log Y = +0.2390 + 0.8051 Log X	0.65 (P ∠ 0.001)
Head length / TL	Log Y = −0.5705 + 0.8954 Log X	0.91 (P ∠ 0.001)	Log Y = −0.1685 + 0.7971 Log X	0.84 (P ∠ 0.001)
Body length / TL	Log Y = −0.2886 + 0.9685 Log X	0.98 (P ∠ 0.001)	Log Y = +0.0782 + 0.8144 Log X	0.80 (P ∠ 0.001)
Pre dorsal length / TL	Log Y = −0.3381 + 0.9595 Log X	0.90 (P ∠ 0.001)	Log Y = +0.0577 + 0.7768 Log X	0.88 (P ∠ 0.001)
Orbit diameter / TL	Log Y = −0.8506 + 0.8565 Log X	0.89 (P ∠ 0.001)	Log Y = −0.1935 + 0.5385 Log X	0.76 (P ∠ 0.001)
Depth through pectoral fin / TL	Log Y = −0.5580 + 0.8806 Log X	0.98 (P ∠ 0.001)	Log Y = −0.1654 + 0.8066 Log X	0.97 (P ∠ 0.001)
Depth through dorsal fin / TL	Log Y = −0.4966 + 0.9700 Log X	0.95 (P ∠ 0.001)	Log Y = −0.2177 + 0.8568 Log X	0.96 (P ∠ 0.001)
Depth through caudal fin / TL	Log Y = −0.8551 + 0.8941 Log X	0.97 (P ∠ 0.001)	Log Y = −0.5678 + 0.7688 Log X	0.95 (P ∠ 0.001)
Post orbit pectoral fin length / TL	Log Y = −0.8107 + 0.9650 Log X	0.75 (P _ 0.001)	Log Y = −0.8482 + 0.9830 Log X	0.85 (P ∠ 0.001)
Caudal length / TL	Log Y = −0.5785 + 0.8505 Log X	0.85 (P ∠ 0.001)	Log Y = −0.1785 + 0.7606 Log X	0.82 (P ∠ 0.001)
Snout length / TL	Log Y = −0.8655 + 0.8142 Log X	0.78 (P ∠ 0.001)	Log Y = −0.1685 + 0.4834 Log X	0.72 (P ∠ 0.001)

*, **TL = 59 mm - 245 mm.

TABLE XI

Statistical analysis of the regression relations of the body characters of *C. garua*.

Body characters	BAIGUL FISHES (MALE)				BAIGUL FISHES (FEMALE)				BAIGUL FISHES (COMBINED)			
	Regression coefficient	S. S. due to regression	Residual S. S.	D. F.	Regression coefficient	S. S. due to regression	Residual S. S.	D. F.	Regression coefficient	S. S. due to regression	Residual S. S.	D. F.
Standard length	0.9907	1.8447	0.0197	85	0.9885	2.3640	0.1104	125	0.9809	4.6085	0.1399	211
Head length	0.9294	1.6255	0.0997	85	0.8817	2.0651	0.7270	125	0.8954	3.8596	0.7754	211
Body length	0.9844	1.8211	6.4029	85	0.9774	2.5576	1.8905	125	0.9685	4.4910	8.3655	211
Pre Dorsal Length	0.9675	1.7585	2.3656	85	0.9583	2.4392	2.2119	125	0.9595	4.4096	4.6062	211
Orbit Diameter	0.8810	1.4505	0.6591	85	0.8450	1.8968	0.2866	125	0.8565	3.5121	0.9841	211
Depth through pectoral fin	0.9454	1.6797	0.0554	85	0.8558	1.9454	8.2861	125	0.8906	3.7144	8.3025	211
Depth through dorsal fin	0.9443	1.6757	0.9907	85	0.9854	2.4756	0.4148	125	0.9700	4.5061	1.4041	211
Depth through caudal fin	0.9546	1.7126	0.6255	85	0.8440	1.8934	0.5885	125	0.8941	3.8291	1.2128	211
Post-orbit to pectoral fin length	0.9872	1.8514	0.6867	85	0.9934	2.6215	4.7701	125	0.9650	4.4601	5.5081	211
Caudal length	0.8641	1.6495	0.5152	85	0.8416	2.2704	0.5709	125	0.8503	4.1729	1.0998	211
Snout length	0.8257	1.3645	0.5784	05	0.8116	1.8417	0.2054	125	0.8142	3.4462	0.0575	211

Body characters	NANAKSAGAR FISH (MALE)				NANAKSAGAR FISH (FEMALE)				NANAKSAGAR FISH (COMBINED)			
Standard length	0.6618	1.3584	0.7665	89	0.9708	2.4142	0.8669	120	0.9051	3.7508	1.6610	210
Head length	0.6375	1.2605	0.4210	89	0.9447	2.3858	3.1992	120	0.7971	3.6630	3.3878	210
Body length	0.6847	1.4539	0.7525	89	0.9156	2.4085	7.8299	120	0.8144	3.8157	9.6952	210
Pre Dorsal Length	0.7535	1.6809	0.6971	89	0.8521	1.7735	0.2716	120	0.7768	3.4792	0.9866	210
Orbit Diameter	0.5972	1.1061	0.2949	89	0.4672	0.5591	1.4288	120	0.5385	1.6709	1.7305	210
Depth through pectoral fin	0.7151	1.5772	0.1805	89	0.9185	2.1612	0.0675	120	0.8066	3.7511	0.2517	210
Depth through dorsal fin	0.6458	1.2954	0.3810	89	0.9581	2.2542	1.0054	120	0.8566	4.0570	1.7326	210
Depth through caudal fin	0.5346	0.8864	0.3814	89	0.9400	2.2852	0.5978	120	0.7608	3.4076	0.7446	210
Post-orbit to pectoral fin length	0.9805	3.0309	0.4515	89	0.9739	2.4984	2.8688	120	0.9830	3.9711	3.3517	210
Caudal length	0.7725	1.2771	0.5511	89	0.7605	2.3192	2.0825	120	0.7606	3.8501	2.6362	210
Snout length	0.5014	1.0256	0.2657	89	0.4038	0.3165	1.3842	120	0.4854	1.6465	1.6556	210

S. S. = Sum of mean deviation square; D. F. = Degrees of freedom.

TABLE III

Variance analysis of the body characters in males and females of *G. chapra*.

Body characters	Deviation from total regression		Deviation from individual regression			Differences			Observed F	5% F	Significance
	D. F.	S. S.	D. F.	S. S.	M. S.	D. F.	S. S.	M. S.			
					BAIGUL SPECIMENS						
Standard length	211	0.1599	210	0.1501	0.0006	1	0.0098	0.0098	1.63	3.89	N. S.
Head length	211	0.7754	210	0.7667	0.0036	1	0.0087	0.0087	2.38	3.89	N. S.
Body length	211	8.3653	210	8.3014	0.0395	1	0.0639	0.0639	1.62	3.89	N. S.
Pre-dorsal length	211	4.6065	210	4.5775	0.0218	1	0.0287	0.0287	1.32	3.89	N. S.
Orbit diameter	211	0.8841	210	0.8837	0.0042	1	0.0004	0.0004	10.50	254.32	N. S.
Depth through pectoral fin	211	8.3053	210	8.2845	0.0394	1	0.0208	0.0208	1.89	254.32	N. S.
Depth through dorsal fin	211	1.4041	210	1.4055	0.0067	1	0.0014	0.0014	4.78	254.32	N. S.
Depth through caudal fin	211	1.2128	210	1.1940	0.0057	1	0.0188	0.0188	3.31	3.89	N. S.
Post orbit to pectoral fin length	211	5.5081	210	5.4588	0.0260	1	0.0493	0.0493	1.89	3.89	N. S.
Caudal length	211	1.0998	210	1.0861	0.0052	1	0.0137	0.0137	2.63	3.89	N. S.
Snout length	211	0.7873	210	0.7838	0.0037	1	0.0035	0.0035	1.06	254.32	N. S.
					NANAKSAGAR SPECIMENS						
Standard length	210	1.6610	209	1.6334	0.0078	1	0.0276	0.0276	3.54	3.89	N. S.
Head length	210	3.5078	209	3.5002	0.0171	1	0.0076	0.0076	2.25	254.32	N. S.
Body length	210	8.6932	209	8.5622	0.0410	1	0.1310	0.1310	3.19	3.89	N. S.
Pre-dorsal length	210	0.9866	209	0.9687	0.0046	1	0.0179	0.0179	3.89	3.89	N. S.
Orbit diameter	210	1.7323	209	1.7257	0.0082	1	0.0066	0.0066	1.24	254.32	N. S.
Depth through pectoral fin	210	0.2517	209	0.2478	0.0012	1	0.0039	0.0039	3.25	3.89	N. S.
Depth through dorsal fin	210	1.7326	209	1.6864	0.0081	1	0.0462	0.0462	5.70	3.89	S.
Depth through caudal fin	210	0.7446	209	0.7392	0.0035	1	0.0054	0.0054	1.54	3.89	N. S.
Post orbit to pectoral fin length	210	3.3317	209	3.3203	0.0159	1	0.0114	0.0114	1.39	254.32	N. S.
Caudal length	210	2.6462	209	2.6334	0.0126	1	0.0128	0.0128	1.02	3.89	N. S.
Snout length	210	1.6556	209	1.6499	0.0079	1	0.0057	0.0057	1.39	254.32	N. S.

D. F. = Degrees of freedom; S. S. = Sum of mean deviation squares;

M. S. = Mean deviation squares; S = Significance; N. S. = Not significance.

TABLE IV

Variance analysis of the body characters of Baigul and Nanaksagar specimens of *G. chapra*

Body characters	Deviation from total regression		Deviation from individual regression			Differences			Observed F	5% F	Significance
	D.F.	S.S.	D.F.	S.S.	M.S.	D.F.	S.S.	M.S.			
Standard length	422	1.8275	421	1.8009	0.0043	1	0.0266	0.0266	6.1860	3.8	S
Head length	422	4.4648	421	4.3632	0.0104	1	0.1016	0.1016	9.7692	3.8	S
Body length	422	17.8247	421	17.0585	0.0405	1	0.7562	0.7662	18.9185	3.8	S
Pre-dorsal length	422	15.8918	421	5.5928	0.0133	1	0.2990	0.2990	22.4812	3.8	S
Orbit diameter	422	2.6405	421	2.6144	0.0062	1	0.0296	0.0296	4.7822	3.8	S
Depth through pectoral fin	422	8.7212	421	8.5540	0.0203	1	0.1672	0.1672	8.2364	3.8	S
Depth through dorsal fin	422	3.2248	421	3.1367	0.0074	1	0.0881	0.0881	11.9054	3.8	S
Depth through caudal peduncle	422	2.0143	421	1.9574	0.0046	1	0.0569	0.0569	12.3695	3.8	S
Post orbit to pectoral fin length	422	8.9462	421	8.8398	0.0210	1	0.1064	0.1064	5.0667	3.8	S
Caudal length	422	3.8387	421	3.7460	0.0089	1	0.0927	0.0927	10.4157	3.8	S
Snout length	422	2.4677	421	2.4429	0.0058	1	0.0248	0.0248	4.2759	3.8	S

D.F. = Degree of freedom; S.S. = Sum of mean deviation squares; M.S. = Mean deviation squares;
S = Significance.

TABLE - V

Average measurements of body characters their percentage and ratios in G. chapra

Body characters	Mean		Parameters	Measurements					
	Baigul Speci-mens*	Nanaksagar Specimens**		Baigul specimens			Nanaksagar specimens		
				Range	Ratio	%	Range	Ratio	%
Total length	129.3±3.1	118.3±2.9	TL / SL	1.1-1.3	1.2	83.5	1.1-1.3	1.2	80.9
Standard length	107.9±2.2	95.8±2.0	TL / HL	3.4-4.1	3.7	27.3	2.5-4.0	3.7	27.4
Body length	72.5±1.5	63.5±1.4	TL/ BL	1.7-1.9	1.8	56.1	1.7-1.9	1.9	63.6
Predorsal length	54.5±1.3	47.8±1.2	TL / PDL	2.3-2.4	2.4	42.2	2.4-2.5	2.5	40.4
Orbit diameter	9.8±0.2	6.9±0.2	TL / OD	11.9-13.7	13.4	7.6	11.8-13.6	13.3	7.5
Depth through pectoral fin	36.8±0.7	33.9 ±0.7	TL / DP	3.1-4.0	3.5	28.5	3.3-3.9	3.5	28.7
Depth through dorsal fin	38.7±0.9	34.9±0.8	TL / DD	3.1-3.7	3.3	30.0	3.2-3.8	3.4	29.5
Depth through caudal peduncle	11.7±0.3	11.1±0.3	TL / DCP	10.3-12.6	11.1	9.1	10.4-11.6	10.6	9.4
Post-orbit to pectoral fin	18.9±0.4	16.9±0.4	TL / PPL	6.3-6.9	6.8	14.6	6.5-7.3	7.0	14.3
Caudal length	31.6±0.6	27.4 ±0.5	TL / CL	3.9-4.5	4.1	24.4	4.1-4.6	4.3	23.1
Snout length	6.9±0.1	6.3±0.1	TL / SnL	16.2-18.9	18.7	5.3	16.7-19.0	18.8	5.9
Head length	35.3±0.7	32.4±0.6	HL / OD	2.9-4.0	3.6	27.9	3.0-3.9	3.6	27.5
			HL / SnL	4.4-5.8	5.1	19.6	4.5-5.8	5.1	19.5

*No. of observations = 212; ** No. of observations = 211.

TABLE VI

Frequency of occurrence of the meristic characters in G. chapra.

A. Scutes

Parameters	Frequency of occurrence			
	Number	Percentage	Number	Percentage
	Baigul specimens*		Nanaksagar specimens**	
No. of pre-pelvic scutes				
15	-	-	4	2.8
16	19	14.6	17	12.0
17	109	83.8	56	39.4
18	2	1.5	65	45.8
No. of post-pelvic scutes				
8	5	3.8	8	5.6
9	36	27.7	84	59.2
10	87	66.9	50	35.2
11	2	1.5	-	-
Total no. of scutes				
25	10	7.7	16	11.3
26	39	30.0	45	31.7
27	78	60.0	67	47.2
28	3	2.3	12	8.5
B. Scales				
No. of lateral line scales				
80	-	-	11	7.7
85	15	11.5	8	5.6
88	18	13.8	17	12.0
92	13	10.0	20	14.1
96	18	13.8	27	19.0
99	21	16.2	31	21.8
103	16	12.3	17	12.0
108	22	16.9	11	7.7
110	7	5.4	-	-
No. of dorso-transverse scales				
10	10	7.7	7	7.7
11	58	44.6	50	35.2
12	44	33.8	48	33.8
13	18	13.8	37	26.1
No. of ventro-transverse scales				
21	41	31.5	37	26.0
22	50	38.5	43	30.3
23	39	30.0	42	29.6
No. of total transverse scales				
32	27	20.8	24	16.9
33	38	29.2	50	35.2
34	35	26.9	36	25.4
35	30	23.1	32	22.5
C. Fin Rays				
No. of dorsal fin rays				
14	45	34.6	35	24.6
15	85	65.4	65	45.8
16	-	-	42	29.6
No. of pectoral fin rays				
12	21	16.2	35	24.6
13	109	83.8	107	75.4
No. of ventral fin rays				
7	19	14.6	25	17.6
8	111	85.4	117	82.4
No. of anal fin rays				
21	98	75.4	31	21.8
22	21	16.2	52	36.6
23	11	8.5	44	31.0
24	-	-	15	10.6
No. of caudal fin rays				
16	35	26.9	38	26.8
17	78	60.0	104	73.2
18	17	13.1	-	-

* No. of observations = 130; ** No. of observations = 142

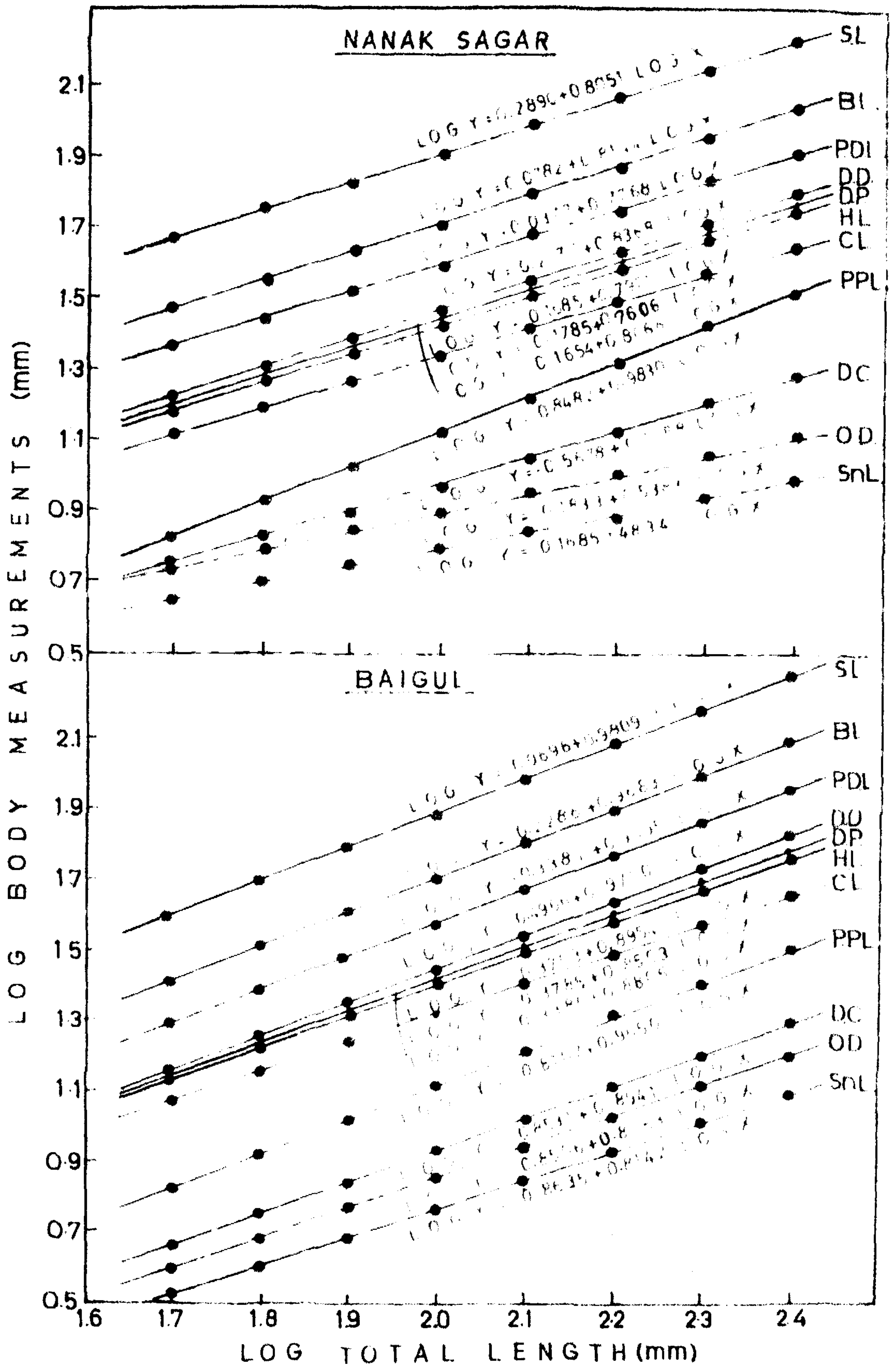
TABLE – VII

Numerical heterogeneity in the meristic characters of G. chapra

		NUMERICAL COUNT OF MERISTIC CHARACTERS									
		Scutes			Scales		Fin rays				
		Pre-Pelvic	Post-Pelvic	Total	Lateral line	Latro-trans-verse	Dorsal	Pectoral	Ventral	Anal	Caudal
BAIGUL SPECIMENS*	Range	16–18	8–11	25–28	85–110	32–35	14–15	12–13	7–8	21–23	16–18
	Mean	16.88	9.66	26.57	97.19	30.52	14.65	12.85	7.85	21.33	16.86
	S.E.	±0.03	±0.05	±0.06	±0.071	±0.09	±0.04	±0.03	±0.03	±0.06	±0.05
NANAKSAGAR SPECIMENS**	Range	15–18	8–10	25–26	80–108	32–35	14–16	12–13	7–8	21–24	16–17
	Mean	17.28	9.30	26.56	92.43	33.53	15.05	12.75	7.82	22.30	16.73
	S.E.	±0.07	±0.06	±0.07	±0.53	±0.09	±0.06	±0.04	±0.03	±0.08	±0.04
VARIABI-LITY	M.D.	0.41	0.37	0.01	4.76	3.01	0.40	0.09	0.03	0.97	0.13
	σ D	0.07	0.07	0.09	0.79	0.13	0.07	0.05	0.04	0.10	0.06
	't'	5.86	5.29	0.11	6.03	23.15	5.71	1.80	0.75	9.70	2.17
	SIGNI-FICANCE	S	S	NS	S	S	S	NS	NS	S	S

* = Number of observation = 130; **Number of observations = 142;
df = 2.70; 't' at 5% = 1.97; 1% = 2.59; S = Significance; N.S.= Not significance; S.E. = Standard error of Mean; M.D. = Mean difference; S.D. = Standard deviation of difference.

Fig. 1. Logarithmic relationships of the various body measurements with the total length of *G. chapra*.



NANAK SAGAR
BAIGUL
SL
BL
PDL
DD
DP
HL
CL
PPL
DC
OD
SnL
LOG BODY MEASUREMENTS (mm)
LOG TOTAL LENGTH (mm)

PART III

B I O L O G Y

O F

GUDUSIA CHAPRA (HAM.)

C H A P T E R   I

FOOD AND FEEDING HABITS

I N T R O D U C T I O N

Trophic ecology of fishes is as old as fishery science. Feeding is known to be an important function of an organism because the growth, development, reproduction etc., all take place at the expense of the energy derived from food (Nikolsky, 1963). According to Chacko & Ganapati (1949) studies on the food and feeding habits of fishes have enormous significance in solving the various problems of pisciculture, because fishing industry can be brought into line with other industries only when a detailed knowledge on the fishes and their food organisms is available. Since ecological observations on fishes help in finding out solutions of fundamental problems of the biological basis of fisheries, all the links in exploitation of the fisheries resources must be based on the knowledge of the mode of life of fishes (Nikolsky, 1963). In other words, proper management and rational exploitation of fishery resources is possible only when various aspects of the natural history of fishes, including growth, breeding, migration, and especially their food and feeding habits are known.

For conclusion on the dietary of a particular species, the qualitative and quantitative changes in its food, during its life span must be taken into consideration. The diet of fish does not remain constant as a result of profound variations in the seasonal abundance of the food items and the changes, though marginal, in the structure of the organs of feeding with growth.

The food and feeding habits of Indian fishes have been studied by several ichthyologists (Khan, 1934; Sarbahi, 1949; Hora, 1940; Mookerjee & Ghosh, 1945; Bapat & Bal, 1950; Pilley, 1953; Sarojini, 1954; Das & Moitra, 1955 a,b; Ali-Kunhi, 1958; Menon & Chacko, 1958; Kareker & Bal, 1958; Vashisht, 1960; Chakraborty & Singh, 1963; David, 1963; Natrajan & Jhingran, 1963; Saigal, 1964; Suseelan & Nair, 1969; Bhatnagar & Karamchandani, 1970; Desai, 1970; Devraj, 1973; Jhingran, 1972, 1973; Jyoti & Malhotra, 1975; Mustafa & Jafri, 1978; Rita & Nair, 1979; Nair & Sobhana, 1980).

Several accounts are also available specifically on food selectivity of fishes (Allen, 1941; Hes & Swartz, 1941; Lewis et al., 1961; Cramer & Marzolf, 1970; Hutchinson, 1971; Burbridge, 1974; Cantin et al., 1974; O'Brien & Vinyard, 1974; Mustafa, 1976; O'Brien et al., 1976; Repsys et al., 1976; Eggers, 1977; Jafri & Mustafa, 1977; Bisson, 1978; Ringler, 1979; Arvindan, 1980; Vinyard, 1980).

Changes in feeding habits during growth have been studied by Thomas (1962). A comprehensive study of forage ratio has been made by Novak & Estes (1974). A modification of Ivlev's electivity index, and the forage ratio has also been presented by Strauss (1979). Correlation between food and body weight was observed by Mookerjee & Sen Gupta (1946). Food and habitat partitioning was investigated by George & Hadley (1979). Information on feeding relations and competition is available in the work of Steven (1930), Hartley (1948), Prakash (1962), Thomas (1962), Maitland (1965) and Werner & Hall (1977). Data on the relationship between gut length and body length is available in the work of Al-Hussaini (1949), Sinha & Moitra (1976), Saxena & Chitray (1964). A detailed account of the morphology and histology of pyloric caeca in different families of fishes has also been given by Rahimullah (1945). The structure of the buccopharyngeal region of fishes with different dietary habits was studied by Kapoor (1957), Sinha & Moitra (1976) and Saxena (1980). However, the diet composition of G. chapra from river Ganga near Allahabad was studied by Jhingran (1972).

Despite vastness and rich biomass productivity of Baigul and Nanaksagar reservoirs the author is not aware of any information on the biology of fishes or other aquatic organisms inhabiting these impoundments. The present work on the trophic ecology of G. chapra (Ham.) from Baigul and Nanaksagar reservoirs deals with the composition of food and foraging intensity in fish of various sizes, maturity stages, and in different seasons of the year. Information has also been presented on selectivity of the food organisms by the fish. Dietary habit of the G. chapra has been correlated with the structural modifications in the organ of feeding.

MATERIALS AND METHODS

Regular monthly samples of G. ghagra were randomly collected from Baigul (number = 414) and Nanaksagar (number=413). Specimens were measured for total length and body weight. These were dissected out, alimentary canal removed soon after the landing of the fish and preserved in 10% formalin. The sampling was done between 9.00 AM to 11.00 AM and between 4.00 PM to 6.00 PM since during these periods the guts were found to contain food items in fresh and identifiable condition. For the study of organs of feeding a deep incision was given through the angle of the jaws, and the roof (palate) and floor of the buccopharyngeal cavity stretched open and washed with water. Various structures were sketched proportionately. The preserved guts were taken out and the fat deposited on their surface removed. The weight and length of the guts were noted and the structures of various parts grossly studied.

Three spieces, each of 5 cm, were cut off from different regions of gut and their contents removed in petridish containing known quantity of water. After proper mixing two sub-samples of measured volume (0.5 ml each) were put on slides separately and examined under microscope. The various planktonic items were identified upto generic level with the help of keys given by Ward & Whipple (1963) and Needham & Needham (1964). The food items were counted and the mean of countings in the sub-samples tabulated. The occurrence of food item in the gut was expressed as a percentage of the total number of the guts examined. The relative abundance of each plankton was expressed as a percentage of the total number of food items in the sub-sample analysed. The proportions of the semi-digested food matter, sand, and macrovegetation pieces were decided by 'point method' as suggested by Nair & Sobhana (1980). After regular practice this method gives satisfactory results.

The intensity of feeding was studied by determining the gastro-somatic index, 'G.S.I.' (gut weight expressed as percentage of body weight). The number of fish with empty guts in each month was expressed as percentage of the total number of specimens examined in that month. The gut length-body length ratio of individual specimens was calculated.

Selectivity of food organisms by G. chapra was analysed by evaluating electivity indices through the equation proposed by Ivlev (1961) and successfully used by Mustafa (1976), Jafri & Mustafa (1977) and Arvindan (1980), etc.

$$E = \frac{ri - pi}{ri + pi}$$

Where, E = electivity index, ri = percentage of food organism in the gut contents, and pi = percentage of the same food item in the environment. Electivity index ranges from -1 (when a food item is rejected outright) to +1 (when food item is highly selected). A zero electivity index serves to signify absence of selectivity.

O B S E R V A T I O N S

The structures of organs of feeding including bucco-pharyngeal region and the gut of *G. ghagra* have been sketched (Figs. 1, 2). The various modifications are in correlation with feeding habits of fish.

Results of the qualitative and quantitative studies on the diet of *G. ghagra* have been presented in Tables I, II and shown graphically (Figs. 3-8). It is evident from the data that this species feeds upon green algae, blue green algae, their spores and zygotes, desmids, diatoms, zooplanktonic crustaceans, rotifers, besides small quantities of macro-vegetation and sand particles. Phytoplankton were encountered in large number throughout the period of investigation and constituted about 52% and a little more than 48% of the food of Baigul and Nanaksagar fish, respectively. The green algae (chlorophyceae) and diatoms (Bacillariophyceae) were the more important components whereas blue green algae (Myxophyceae), desmids (Desmidiaceae) occurred in small numbers and their frequency of occurrence was also lower. The zooplanktonic microcrustaceans including the cladocerans and copepods formed 1.7% and 4% of the gut contents of *G. ghagra* from Baigul and Nanaksagar, respectively. Rotifers averaged 1.7% (Baigul) and 1.2% (Nanaksagar).

As much as 84-87% of the guts analysed, showed the presence of small pieces of macrovegetation whose contribution to the total dietary did not exceed 3%. Likewise, the frequency of occurrence of sand was 81% (Baigul specimens) and 94.3% (Nanaksagar specimens) but they formed not more than 5.5% of the gut contents. Greenish coloured semi-digested (unidentified) matter occurred in most of the guts, with variable proportion.

The food items found in the guts of fishes of different sizes have been listed in Table III and incorporated in Fig. 9. In successively higher size groups of G. chapra there was a decrease in the relative proportion of phytoplankton and an increase in zooplankton. While the proportion of sand was low in the dietary of smaller specimens (I size group), it did not differ appreciably in the size groups II-V. Intake of macrovegetation increased gradually with the growth of the fish.

Monthly variations in the gastrosomatic index of male and female G. chapra can be read off from Table IV and Fig. 10. The pattern of changes in this parameter revealed that feeding intensity was maximum in May (Baigul fish) and May-June period (Nanaksagar fish), but declined catastrophically thereafter. It remained low throughout the monsoon season. After the monsoon season was over the intake of the food matter increased appreciably. The data were substantiated by percentage of empty guts which flustuated reciprocally vis-a-vis the gastrosomatic index.

Observations concerning the feeding intensity of the size groups tabulated (Table V) and plotted in Fig. 11 suggest that foraging activity is higher in younger individuals and decreases in higher size groups upto a length of 175 mm. A corresponding increase in the percentage of empty guts substantiates it. Further growth of the individual to a maximum of 215 mm was associated with better intake of the food.

Information on feeding intensity in fishes of different stages of maturation is given in Table VI and Fig. 12. Feeding activity was fairly higher in immature virgins compared to maturing virgins and recovering spent individuals. After registering a slight increase the values declined in ripe and spent individuals progressively.

The amount of plant matter (phytoplankton and macrovegetation) was somewhat higher in the diet of Baigul specimens whereas in those inhabiting the Nanaksagar, zooplanktonic microcrustaceans substituted part of the plant matter. G. chapra from both the reservoirs utilized almost the same quantity of the sand.

The percentage of various planktonic forage organisms in contents of guts and environments (Baigul and Nanaksagar) of G. chapra alongwith the electivity indices for these food items have been tabulated (Table VII). Selectivity is indicated by the difference in the two sets of da a vis-a-vis planktonic composition of the environment and that of food in the gut. An interesting fact is that with rare exceptions, the preferences for different types of plankton in Baigul and Nanaksagar were identical although with different degrees. Of the 19 genera of green algae encountered *Tetraedron*, *Selenastrum*, *Coelastrum*, *Kirchneriella*, *Oocystis*, *Oedogonium*, *Tetraedriella* *Arthrodesmus* were negatively selected and two namely, *Scenedesmus*, *Dinobryon* were shown no selectivity whatsoever and the rest including *Pediastrum*, *Botryococcus*, *Ankistrodesmus*, *Crucigenia*, *Phacus*, *Protococcus*, *Glenodinium*, *Zygnema* and *Euglena* were positively selected by G. chapra in Baigul. In Nanaksagar where only 13 genera of green algae were found to occur, the fish selected against *Tetraedron*, *Oedogonium*, *Tetraedriella* and prefered feeding on *Pediastrum*, *Botryococcus*, *Ankistrodesmus*, *Scenedesmus*, *Crucigenia*, *Phacus*, *Glenodinium*, *Zygnema*, *Dinobryon* and *Euglena*.

Negative selection of the fish was clearly evident for both the two genera of blue green algae viz., *Oscillatoria* and *Anabaena* recorded from the two reservoirs. The algal spores and zygotes were not favoured in either reservoir.

Regarding the desmids, out of the 5 genera *Closterium*, *Cosmarium*, *Staurastrum*, *Gonatozygon* and *Mesotaenium*, the first three were selected at the cost of the last two in case of Baigul inhabitants. A similar trend was discernible in Nanaksagar individuals except that *Mesotaenium* did neither occur in the gut nor in the environment.

Amongst the diatoms, the avoidance was seen for *Tabellaria*, *Gyrosigma* and *Surirella*, preference for *Cocconeis*, *Rhopalodia*, *Cyclotella*, *Melosira*, *Diatoma*, *Nitzschia*, *Synedra*, *Navicula*, *Epithemia*, *Amphora*, *Fragilaria*, *Eunotia* by *G. chapra* in Baigul. *Tabellaria* and *Eunotia* did not occur in Nanaksagar and the remaining genera except *Gyrosigma* were predilected by the teleost.

Concerning the zooplanktons, the microcrustaceans formed a larger percentage as compared to the rotifers. It is evident from the results that *Bosmina*, *Daphnia*, *Simocephalus*, *Macrothrix*, *Cyclocypris* were selected and *Canthocamptus* was avoided in Baigul. In Nanaksagar, all these food items including also *Canthocamptus* and the additional *Pseudosida*, *Eubranchipus* were selected positively and *Leptodora* negatively.

Rotifers were represented by only three genera, *Keratella*, *Brachionus* and *Trichocerca*. The last one did not find favour with the fish quite unlike the former two genera.

D I S C U S S I O N

Study of the gut contents and the structure of the organs concerned with feeding suggests omnivory in *G. chapra*. Mouth of the fish is oblique and terminal, buccal cavity is depressed, devoid of teeth, gill rakers are long, filamentous, numerous and closely set. Pharynx leads into short oesophagus which opens into stomach. Cardiac part of stomach is elongated and tubular but pyloric region is small, bulbus, thick walled and hard. At the junction of pylorus and intestine are present numerous pyloric caeca. Intestine is thin walled. These modifications are in keeping with a predominantly planktivorous diet. Gizzard-like pyloric stomach and its inner hard cuticular lining perhaps serve to triturate the macrovegetation and sand which form but a small proportion of the food. Presence of small bulbus and muscular stomach does not necessarily indicate the predatory nature of *G. chapra*. Kapoor (1954, 1957) and Al-Hussaini (1947, 1949) concluded that the morphology of stomach is not always closely related to nature of diet. Presence of large number of pyloric caeca (100-120) in this species may serve to increase the area for storage and absorption of food, to compensate for the length of the intestine which is shorter compared to those in planktivorous fishes in general. Similar views have been expressed by Rahimullah (1945) and Kapoor (1954).

Several workers (Sarbahi, 1940; Mookerjee & Sen Gupta, 1946; Das & Moitra, 1955 a,b; Khan, 1972) have sought to explain the correlation between gut length and nature of diet. The ratio reported for *Labeo fimbriatus* is 1:22 and for *Labeo kontius* is 1:11 (Ali-Kunhi & Rao, 1951), for *Cirrhina mrigala* is 1:24 (Kamal, 1971), for *Cirrhina reba* is 1:10 (Sinha & Moitra, 1976). The gut length-body length ratios of *Labeo rohita*, *Eutropiichthys vacha*, *Notopterus chitala*, *Ophiocephalus* *striatus* and *Bagarius bagarius* have been worked out to be 1:12, 1:0.43, 1:0.40, 1:0.30, 1:0.80, respectively (Das & Moitra, 1955). Saxena & Chitray (1964) documented the gut length-body length ratios of *Puntius sarana*, *Clupisoma garua*, *Heteropneustes fossilis*, *Ompok bimaculatus* and *Clarias batrachus* as 1:2, 1:1.3, 1:1.3, 1:1.1 and 1:0.6, respectively. A comparison of such ratios in fishes with widely different feeding habits support omnivory, with distinct inclination towards planktivory in *G. chapra*.

Schuster (1949) observed that the relation between gut length and body length of *Chanos chanos* varied with the type of food. Mookerjee & Sen Gupta (1946) reported that the ratio in the same species changed with changeover in the diet during growth in early phase of life. In the present study gut length-body length ratio of *G. chapra* of both the reservoirs fluctuated from 1:1.3 to 1:1.8 but any definite trend of change with size was not discernible. The difference in the ratio between Nanaksagar and Baigul individuals was too little to be linked with differential feeding activity. It can be genetic one. Jhingran (1972) observed no orientation in the diet of *G. chapra* from zooplankton to phytoplankton or vice-versa during increase in size.

Small percentage of sand in and absence of detritus from the gut of *G. chapra*, together with the dominance of algae and green coloured mass reveal that the fish is not a bottom feeder.

Enquiries from experienced fishermen and skilled staff support this view. Unlike the marine habitat, the ecological zones in freshwater bodies based on the physical and chemical nature of the medium and fauna and flora are not very sharply demarcated from each other specially where the depth does not exceed 10-15 feet and the water level is controlled by Irrigation Department in the case of Baigul and Nanaksagar reservoirs. Fish inhabiting such environments exploit both midwater and surface zones for food procurement. Based on the abundance of cladocerans and some insects on the surface water as well as in the gut of the fish from rivers Jhingran (1972) opioned that G. chapra is mainly a surface feeder but expressed the view that the fish may also explore other zones of the habitat as indicated by the occurrence of bottom fauna, though in meagre quantities. Predominance of green algae and poor occurrence of cladocerans in the gut seem to be related to relatively low productivity of the zooplankton in the reservoirs. Despite its preference for zooplanktons, a non-migratory species like G. chapra can not afford restricting its diet to only a fewer variety of food items, and as such, feeds upon those items which are abundantly available in the habitat in different seasons.

The results of the present study leave no doubt that immature fishes feed heavily but their foraging activity declines with the advent of gonad build-up. The activity fluctuates and becomes low when they are ripe and ready to spawn as a result of an intrinsic factor in the form of physiological emergency in the body. However, lower feeding intensity following spawning which relieves the fish of the physiological strain and enables a return to normalcy is under the influence of environmental (extrinsic) factors, mainly the rise in water level.

The coincidence of low feeding with peak breeding has been noticed by many workers. Hickling (1933), Fage & Veillet (1938), Menon (1950); Bhimachar & George (1952); Kareker & Bal (1958), Desai (1970), observed a decrease in the rate of feeding and amount of food consumed with the maturation of gonads. Jhingran (1961) found decline in feeding intensity of Gadusia chapra during peak breeding season. He (1966) further noticed that sexual cycle affected the feeding intensity of G. chapra. Contrary to these findings, Bhatnagar & Karamchandani (1970) while working on Labeo fimbriatus reported that low feeding intensity, even in immature fish with underdeveloped gonads, is entirely due to inadequate availability of food organisms in the flooded river and not in any way related to maturity. In the present study the feeding intensity was found high in fish with inactive gonads due to a number of factors including larger space in the abdominal cavity and high metabolic rate. Decreased feeding activity in ripe individuals during breeding season as evidenced by low values of gastrosomatic index and high percentage of empty guts, may be attributed to gonad build-up, permitting only a limited space in the abdominal cavity for accomodation of ingested materials as well as reduction in the food per unit volume in the flooded environment. This accounts for decline in feeding activity of G. *chapra* in the monsoon season. Following this period feeding becomes more intensive as a result of spaceous abdominal cavity, allowing larger amount of food in gut, increased metabolic activity, high concentration of food items and above all the determination of fish to procure food in quantities sufficient enough to recover it from the stress in preceeding phase of life and preparation of gonads for the subsequent breeding. Peak summer (June) and winter (January) seasons were observed to curtail the intensity of feeding. Such an influence of temperature has been reviewed by Vasisht (1960).

Feeding intensity of small individuals was higher because of their faster metabolic rate. They require relatively more quantity of food to maintain unit weights of their bodies than do large individuals. It is for this reason that the underyearlings strive to exploit the lower levels of food pyramid, because of the increase in food supply with drop in trophic level in an ecosystem. The tendency of the substitution of a portion of algal dietary component by zooplankton in larger specimens, on howsoever small scale, is a pointer to this natural fact.

Preference of the various types of planktonic organisms as indicated by the positive electivity indices may be related to their abundance, accessibility, digestibility and the ability of the fish to assimilate them, irrespective of the environment the fish inhabits. The behaviour of predator as well as that of the prey influence the electivity index. Despite their abundance in the environment not all types of organisms are easily vulnerable to fish; they may be quite evasive. In this category Novak & Estes (1974) classified those organisms which remain concealed under submerged stones or macrovegetation, making only infrequent appearance and have inconspicuous colour. The diurnal movement of plankton in vertical plane has been observed to reduce vulnerability (Wright et al., 1980). The findings of Mathur (1973), Lewis et al. (1974), Mustafa (1976), Jafri & Mustafa (1977) and Arvindan (1980) make it abundantly clear that feeding opportunities of predators, favourable occassional chance, availability, abundence and mobility of the prey items influence the food selectivity. According to O'Brien et al. (1976), Eggers (1977) the size frequency distribution and the density of prey as also their respective reactive distance effect selection. Drenner et al. (1978) advocated that prey selectivity in non-visual planktovores can shift from size specificity to current-sensing and evasion capability.

In a well reasoned article Snow (1971) concluded that a fish at satiety may refuse to accept a food item which it selects and even makes determined search for the same, when hungry. Obviously, inclination of fish towards a food item is stimulated by hunger, which induces a 'reflex-like' response in the presence of prey. Any food item is, therefore, of variable selectivity.

Materialistic approach in discriminate feeding is certainly a factor that can not be overlooked. Fish shows interest in food which yield energy exceeding that the predator looses in procurement drive. Naturally, the uneconomical types with poor calorific return are rejected. The inherent instinctive property of G. chapra to select or avoid food items out of the totality of the food complex in the environment may also be an influential factor.

A comparison of the electivity indices for phyto- and zooplankton in G. chapra from Jaigul and Nanaksagar reveal differences within the positive as well as negative sets of data, which invariably imply the degrees of selection and avoidance as the case may be. This serves to prove the habit of opportunistic feeding depending upon the relative density of food items in environments, and suggests the fish as a versatile feeder. Remarkable success of G. chapra in the two reservoirs can not but be a manifestation of such a forage strategy. Mustafa (1976), while working on Rasbora daniconius explained in detail the ecological as also physiological adaptive importance of this phenomenon. To deal with abundance of a particular kind of food item the enzyme secretion is quantitatively modified accordingly so that the fish thrives well. The hypothesis presented by Popova & Syntina (1977) is quite in tune with those observations. It is pointed out that community in an ecosystem gets stabilized as predator hunts upon the numerically most superior food item(s) and switches over to another prey if abundance of its first priority food falls below a critical level. This prevents upheavals in the environmental food pyramid.

TABLE I

Monthly variations in the frequency of occurrence (in parentheses) and abundance of food items in the gut of *G. chapra* from Baigul reservoir.

Food items	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean
[illegible]	0.3 (64.5)	0.3 (67.6)	0.1 (31.4)	– (11.4)	– (5.0)	0.1 (28.2)	0.1 (18.6)	0.3 (90.5)	– (7.4)	0.1 (46.1)	– (7.1)	– (3.5)	0.1±0.0 (30.7±7.8)
[illegible]	– –	0.1 (35.3)	0.4 (60.0)	0.8 (94.3)	– –	0.5 (89.1)	– (25.2)	0.1 (39.0)	– –	– (7.8)	– –	– (17.8)	0.1±0.2 (30.5±9.9)
Pediastrum	1.0 (100.0)	0.7 (76.4)	0.8 (54.3)	0.2 (51.4)	0.3 (15.0)	0.5 (97.8)	0.3 (65.1)	1.0 (97.5)	0.3 (50.2)	0.4 (64.6)	– (3.6)	0.1 (32.1)	0.5±0.1 (61.4±9.3)
[illegible]	4.5 (100.0)	7.3 (100.0)	4.3 (91.4)	3.3 (100.0)	2.6 (35.0)	5.7 (97.8)	3.8 (100.0)	3.3 (100.0)	2.1 (70.2)	1.7 (52.3)	0.8 (50.0)	0.8 (89.3)	3.4±0.4 (85.5±6.3)
Coelastrum	0.6 (77.4)	0.1 (26.5)	0.1 (20.0)	0.2 (31.4)	0.1 (5.0)	0.4 (69.5)	0.2 (35.0)	– –	– (3.7)	– (7.8)	– –	– –	0.1±0.1 (25.0±7.7)
Ankistrodesmus	1.5 (96.7)	1.8 (97.0)	0.3 (48.6)	0.2 (40.0)	– –	0.2 (54.3)	0.1 (30.2)	0.3 (61.0)	0.3 (22.0)	0.2 (65.4)	0.2 (32.1)	0.3 (64.3)	0.5±0.1 (51.0±0.3)
Scenedesmus	3.0 (100.0)	3.1 (100.0)	1.7 (91.4)	1.1 (100.0)	1.0 (37.5)	0.7 (82.6)	0.9 (97.6)	1.6 (97.5)	0.5 (83.0)	0.5 (64.6)	0.1 (32.1)	0.2 (71.4)	1.2±0.2 (79.8±7.0)
Kirchneriella	– –	– (11.8)	0.1 (11.4)	– –	– –	0.2 (30.4)	0.2 (20.9)	0.1 (10.5)	– (14.0)	0.1 (25.1)	– –	– (3.6)	0.1±0.0 (11.3±3.0)
Oocystis	– –	– –	– (5.7)	– –	– (12.5)	1.0 (95.6)	0.2 (48.8)	– (7.3)	– (3.7)	– (3.8)	– –	– (7.2)	0.1±0.0 (15.4±8.2)
[illegible]	– –	0.1 (15.5)	0.1 (20.0)	0.6 (77.1)	– (15.0)	0.1 (82.6)	– (2.3)	– (2.4)	– –	– (11.5)	– –	– –	0.1±0.1 (19.5±8.5)
[illegible]	1.3 (100.0)	1.0 (97.0)	0.7 (77.1)	0.6 (65.7)	– (2.5)	0.6 (97.8)	0.7 (74.4)	0.2 (61.0)	0.1 (20.6)	0.1 (50.0)	0.1 (32.1)	– (25.0)	0.6±0.2 (59.3±9.2)
Phacus	– (6.4)	0.1 (26.5)	0.1 (11.4)	– (25.6)	– (5.0)	– –	0.4 (21.0)	– (4.9)	0.3 (40.7)	0.1 (42.3)	0.3 (60.7)	0.1 (42.8)	0.1±0.1 (25.9±5.6)
[illegible]	1.1 (93.5)	0.6 (91.2)	0.9 (82.8)	0.2 (94.3)	– (7.5)	0.2 (54.3)	0.1 (21.0)	– (4.9)	– (0.1)	– (19.2)	– –	– –	0.3±0.2 (36.4±10.6)
[illegible]	– –	0.2 (35.3)	– –	– –	– –	0.1 (69.5)	– –	0.1 (26.9)	– (7.4)	0.1 (39.4)	– (7.1)	– (10.7)	0.04±0.0 (16.3±6.3)
[illegible]	16.2 (100.0)	15.2 (100.0)	18.4 (100.0)	14.6 (100.0)	15.2 (87.5)	17.4 (100.0)	14.6 (100.0)	11.5 (100.0)	15.6 (66.6)	10.2 (88.4)	3.2 (71.4)	8.0 (89.3)	13.3±1.3 (91.8±3.4)
Arthrodesmus	0.1 (20.0)	0.1 (50.0)	– (8.5)	– –	– –	– –	– (9.3)	– (4.9)	– –	– (3.8)	– (3.6)	– –	0.02±0.0 (9.1±4.4)
[illegible]	3.7 (100.0)	4.9 (100.0)	5.6 (100.0)	2.5 (100.0)	0.8 (60.0)	6.0 (97.8)	15.3 (95.3)	20.7 (100.0)	5.5 (68.0)	2.9 (88.4)	2.6 (71.4)	2.1 (78.6)	6.1±1.7 (87.9±4.5)
[illegible]	– –	– –	– –	– –	2.5 (65.0)	0.1 (82.6)	– –	– –	– –	– –	– –	– –	0.2±0.2 (12.3±8.3)
GREEN ALGAE	33.3 ±2.6	35.6 ±2.0	33.6 ±3.2	24.3 ±1.5	22.6 ±3.7	33.8 ±2.4	36.9 ±3.3	39.2 ±2.7	24.7 ±3.3	16.4 ±1.0	7.3 ±1.5	11.6 ±2.6	26.6±3.0
Oscillatoria	0.9 (35.5)	0.6 (56.0)	0.4 (22.8)	0.3 (11.4)	0.1 (10.0)	0.7 (4.3)	0.3 (37.2)	0.8 (56.1)	0.3 (65.6)	0.2 (42.3)	– –	0.1 –	0.4±0.1 (20.5±6.8)
[illegible]	0.1 (12.9)	0.2 (20.6)	0.1 –	– –	– –	0.1 –	0.1 (2.3)	0.2 (29.2)	0.1 (10.5)	0.1 (61.5)	– (10.7)	0.1 –	0.1±0.0 (15.0±5.3)
BLUE GREEN ALGAE	1.0 ±0.2	0.8 ±0.1	0.5 ±0.1	0.3 ±0.1	0.1 ±0.0	0.8 ±0.2	0.4 ±0.1	1.0 ±0.2	0.4 ±0.1	0.3 ±0.1	– –	0.2 ±0.1	0.5±0.1
[illegible]	1.9 (100.0)	7.3 (100.0)	3.5 (97.8)	2.2 (100.0)	0.3 (50.0)	1.3 (95.6)	0.9 (74.4)	3.0 (97.5)	0.1 (25.9)	1.1 (88.4)	0.3 (67.8)	0.3 (78.6)	1.9±0.5 (81.8±6.8)
[illegible]	0.8 (87.7)	0.2 (64.7)	0.4 (48.6)	0.2 (45.7)	0.1 (25.0)	– (4.3)	0.1 (16.5)	0.1 (17.0)	– –	– (15.6)	0.1 (14.2)	– –	0.2±0.1 (26.8±6.9)
[illegible]	1.6 (96.7)	2.0 (97.0)	1.3 (94.3)	1.0 (100.0)	0.1 (22.5)	0.5 (91.3)	0.5 (69.8)	0.3 (87.0)	0.1 (20.6)	0.3 (73.1)	– (3.6)	– (17.8)	0.6±0.1 (65.3±10.5)
[illegible]	0.2 (38.7)	0.5 (79.4)	0.2 (45.7)	0.1 (22.8)	– (7.5)	0.5 (97.9)	0.7 (85.7)	0.3 (68.3)	– (7.4)	0.1 (38.4)	– (14.2)	– (3.6)	0.2±0.1 (42.3±9.3)
[illegible]	0.04 (12.9)	– –	– –	– –	0.1 (25.0)	0.1 (15.0)	– (2.3)	– (0.7)	– –	– (3.8)	– –	– –	0.02±0.0 (5.5±2.5)
DESMIDS	4.5 ±0.4	10.0 ±0.6	5.4 ±0.5	3.5 ±0.2	0.6 ±0.1	2.4 ±0.2	2.2 ±0.3	3.8 ±0.5	0.2 ±0.0	1.5 ±0.2	0.4 ±0.1	0.3 ±0.0	2.9±0.6
Cocconeis	0.8 (71.0)	1.1 (91.2)	1.1 (82.8)	0.4 (62.8)	0.0 (10.0)	0.3 (69.5)	0.3 (55.8)	0.2 (64.3)	0.1 (20.6)	– (30.8)	0.1 (12.2)	– (10.7)	0.4±0.1 (49.4±8.5)
[illegible]	– –	0.3 (67.6)	7.0 (97.0)	8.0 (100.0)	0.6 (60.0)	1.1 (97.8)	1.3 (90.7)	0.4 (70.0)	0.1 (10.5)	– –	– –	– (7.2)	1.5±0.6 (51.4±12.5)
[illegible]	3.3 (100.0)	3.8 (100.0)	1.9 (94.3)	0.5 (82.8)	0.1 (7.5)	0.2 (50.0)	– (4.6)	0.2 (64.3)	– –	– –	0.2 (21.4)	– (3.6)	0.9±0.3 (44.0±12.2)
Melosira	4.6 (100.0)	6.8 (100.0)	2.0 (88.6)	3.3 (100.0)	0.2 (32.5)	0.6 (76.0)	2.3 (93.4)	7.4 (95.1)	1.3 (63.0)	2.1 (18.4)	0.6 (39.2)	2.2 (39.3)	2.8±0.7 (75.8±7.4)
Diatoma	3.4 (100.0)	2.4 (100.0)	2.9 (94.3)	4.4 (100.0)	2.3 (95.0)	1.6 (97.8)	1.7 (97.6)	0.3 (56.1)	0.2 (45.1)	0.5 (18.4)	– –	0.3 (85.7)	1.8±0.4 (79.4±8.7)
Tabellaria	– –	– (17.7)	– –	0.1 (8.5)	– (10.0)	– –	0.3 (27.8)	– –	– –	– –	– –	– –	0.03±0.0 (5.3±2.6)
[illegible]	– –	– –	– –	– –	– (15.0)	– –	– (2.3)	– (7.3)	– –	– –	– –	– –	0.01±0.0 (2.0±1.3)
Nitzschia	2.5 (100.0)	2.6 (100.0)	6.4 (100.0)	6.9 (100.0)	1.7 (72.5)	1.3 (97.8)	1.7 (97.6)	0.5 (30.5)	0.2 (45.1)	4.2 (88.4)	0.3 (46.4)	0.6 (89.3)	2.4±0.5 (85.0±5.7)
Synedra	3.1 (100.0)	6.2 (100.0)	1.4 (88.6)	1.4 (100.0)	0.4 (42.5)	0.3 (91.3)	1.3 (97.6)	4.3 (97.5)	5.7 (65.0)	10.0 (88.4)	6.2 (39.2)	8.1 (53.5)	4.0±0.7 (80.1±6.8)
Navicula	2.4 (100.0)	1.4 (97.0)	1.2 (91.4)	2.7 (97.1)	0.7 (37.5)	1.0 (97.8)	1.4 (90.7)	0.8 (97.5)	0.1 (10.5)	0.8 (88.4)	0.1 (32.1)	0.2 (53.5)	1.1±0.2 (75.1±8.8)
[illegible]	2.1 (93.5)	1.2 (82.3)	2.8 (65.7)	2.9 (91.4)	0.2 (2.5)	1.3 (41.3)	2.3 (16.2)	0.8 (43.9)	– (3.7)	0.1 (42.3)	0.1 (7.1)	0.1 (17.8)	1.2±0.3 (38.8±10.4)
Amphora	– –	0.2 (61.7)	0.2 (42.8)	1.6 (100.0)	0.5 (60.0)	0.1 (36.9)	0.1 (55.5)	0.3 (78.0)	0.1 (33.3)	– (11.5)	0.1 (17.8)	0.1 (32.1)	0.3±0.1 (44.1±8.2)
[illegible]	0.4 (54.8)	0.2 (35.5)	0.3 (37.5)	0.6 (88.6)	– (10.0)	0.3 (30.4)	1.0 (76.7)	0.3 (65.0)	– (7.4)	– –	– –	– –	0.3±0.1 (35.5±9.3)
Surirella	– –	– (6.8)	– (2.0)	– (2.8)	– –	0.5 (45.6)	0.1 (32.5)	– (7.3)	– –	– –	– (7.1)	– –	0.05±0.0 (8.9±4.2)
Fragilaria	0.9 (100.0)	0.3 (64.7)	0.1 (11.4)	– –	– –	0.1 (67.4)	0.1 (40.9)	0.5 (90.2)	0.2 (33.3)	1.7 (88.4)	0.2 (25.0)	0.2 (67.0)	0.4±0.1 (49.7±10.2)
DIATOMS	25.5 ±1.5	26.5 ±1.4	27.3 ±2.4	32.8 ±1.3	6.7 ±0.5	12.0 ±1.2	14.0 ±1.2	16.1 ±1.5	10.0 ±1.3	10.4 ±1.0	7.9 ±0.5	11.8 ±1.2	18.1±1.8
[illegible]	0.5 (70.0)	0.6 (90.0)	0.3 (50.0)	0.2 (45.0)	0.1 (35.0)	0.2 (40.0)	0.2 (60.0)	0.4 (75.0)	0.5 (85.0)	0.1 (30.0)	– –	0.1 (35.0)	0.3±0.1 (51.0±5.5)
[illegible]	0.3 (60.0)	0.4 (75.0)	0.3 (50.0)	0.3 (55.0)	0.1 (30.0)	0.2 (56.0)	0.2 (60.0)	0.3 (65.0)	0.3 (80.0)	0.1 (35.0)	0.1 (30.0)	0.2 (45.0)	0.3±0.03 (54.0±3.5)
[illegible]	0.5 (75.0)	0.6 (80.0)	0.4 (80.0)	0.3 (45.0)	0.1 (25.0)	0.3 (45.0)	0.4 (50.0)	0.5 (65.0)	0.7 (85.0)	0.2 (36.5)	0.1 (25.5)	0.2 (48.5)	0.4±0.04 (54.5±4.6)
[illegible]	0.2 (35.0)	0.4 (50.5)	0.2 (35.0)	0.2 (40.5)	– –	0.3 (50.0)	0.4 (65.5)	0.4 (80.5)	0.6 (75.0)	0.1 (20.0)	– –	0.1 (20.5)	0.2±0.04 (36.8±5.5)
[illegible]	0.2 (27.5)	0.3 (40.5)	0.1 (20.0)	0.1 (10.0)	– –	0.2 (25.5)	0.3 (45.2)	0.4 (55.4)	0.4 (60.5)	0.1 (10.7)	– –	0.2 (26.5)	0.2±0.03 (31.4±5.3)
[illegible]	0.3 (40.5)	0.5 (65.5)	0.3 (45.4)	0.2 (40.0)	– –	0.3 (50.0)	0.4 (55.4)	0.5 (65.0)	0.7 (75.0)	0.2 (20.0)	– –	0.2 (32.5)	0.3±0.1 (45.1±5.3)
MICRO-CRUSTACEANS	2.0 ±0.2	2.9 ±0.4	1.8 ±0.4	1.4 ±0.3	0.3 ±0.1	1.5 ±0.5	2.0 ±0.5	2.5 ±0.5	3.4 ±0.6	0.8 ±0.2	0.2 ±0.1	1.0 ±0.2	1.7±0.2
[illegible]	2.5 (100.0)	1.9 (100.0)	1.8 (95.5)	1.5 (75.0)	0.3 (65.5)	1.4 (50.5)	2.6 (90.2)	2.3 (95.5)	2.4 (100.0)	0.2 (50.2)	0.2 (17.5)	0.5 (57.2)	1.1±0.2 (77.8±5.9)
[illegible]	0.5 (95.0)	0.4 (75.0)	0.4 (80.0)	0.6 (90.0)	0.2 (65.0)	0.6 (100.0)	1.0 (87.5)	0.2 (66.5)	– –	– –	– –	0.4 (70.5)	0.4±0.1 (59.8±0.5)
[illegible]	0.2 (45.5)	0.3 (56.0)	0.1 (35.5)	0.2 (57.0)	0.1 (25.0)	0.3 (75.4)	0.5 (60.3)	0.1 (27.4)	– –	– –	– –	0.2 (32.8)	0.2±0.04 (37.7±6.9)
ROTIFERS	3.2 ±0.4	2.6 ±0.4	2.3 ±0.3	2.3 ±0.2	0.6 ±0.2	2.3 ±0.4	4.0 ±0.4	0.6 ±0.1	0.4 ±0.1	0.2 ±0.1	0.2 ±0.0	1.1 ±0.0	1.7±0.3
MACRO-VEGETATION	1.5 ±0.5	1.8 ±0.3	3.2 ±0.6	4.4 ±0.6	5.0 ±0.8	2.3 ±0.3	2.7 ±0.3	3.0 ±0.3	5.3 ±0.6	1.5 ±0.3	0.7 ±0.2	1.3 ±0.3	2.7±0.3
SAND PARTICLES	7.3 ±0.8	7.1 ±0.6	4.0 ±0.5	5.0 ±0.5	0.5 ±0.8	7.4 ±0.5	4.7 ±0.3	7.0 ±0.5	0.5 ±0.5	0.8 ±0.5	1.9 ±0.6	4.3 ±0.5	5.2±0.6
SEMI DIGESTED FOOD MATTER	20.0 ±2.5	11.4 ±2.7	10.8 ±1.8	22.7 ±2.0	53.0 ±4.5	35.2 ±2.5	30.1 ±2.5	26.4 ±2.8	46.6 ±0.8	50.1 ±3.0	60.3 ±2.6	65.8 ±2.6	39.3±4.8
ALGAL SPORES AND PIECES	3.7 ±0.1	1.4 ±0.2	1.2 ±0.2	1.4 ±0.2	1.0 ±0.3	2.3 ±0.2	2.2 ±0.4	0.4 ±0.1	0.5 ±0.2	1.0 ±0.2	1.1 ±0.3	2.6 ±0.2	1.6±0.2

± = Standard error of mean.

TABLE - III

Major groups of food items (percentage) in the diet of different size groups of *G. chapra*

Major Food items	Size groups (mm)				
	I (16-55)	II (56-95)	III (96-135)	IV (136-175)	V (176-215)
			BAIGUL SPECIMENS		
Green algae	54.3±4.8	42.1±2.3	30.3±3.9	23.3±4.2	17.6±4.4
Blue green algae	0.8±0.2	0.7±0.2	0.7±0.2	00.5±0.1	0.5±0.2
Desmids	5.9±1.7	5.9±1.4	3.1±0.8	2.5±0.7	2.1±0.7
Diatoms	23.0±4.5	20.3±3.1	16.6±3.5	15.4±3.9	14.5±3.2
Microcrustaceans	0.6±0.2	1.4±0.5	1.7±0.4	1.8±0.4	2.7 ±0.6
Rotifers	1.9±0.3	1.9±0.3	1.5±0.2	1.9±0.3	2.1±0.4
Macrovegetation	0.6±0.2	1.1±0.3	2.2±0.3	3.0±0.3	3.5±0.6
Sand + Mud	2.7±1.2	5.9±1.3	5.1±0.9	6.0±1.0	6.5±1.1
Semi-digested food materials	7.0±2.5	18.2±5.5	37.3±7.1	44.2±7.4	49.3±7.5
Algal spores and zygotes	3.2±0.7	2.5±0.6	1.5±0.4	1.5±0.3	1.2±0.2
			NANAKSAGAR SPECIMENS		
Green algae	52.0±4.0	38.2±4.0	29.1±3.6	26.0±3.5	20.0±3.8
Blue green algae	0.5±0.1	0.4±0.1	0.3±0.1	0.2±0.1	0.1±0.1
Desmids	5.1 ±0.4	4.5±0.3	2.8±0.3	1.4±0.3	1.0±0.2
Diatoms	21.5±3.0	19.2±2.4	18.1±2.2	15.0±1.9	13.1±1.7
Microcrustaceans	2.0±0.8	2.2±0.5	2.5±0.3	3.7±0.6	3.9±0.4
Rotifers	0.5±0.2	0.8±0.2	1.2±0.3	1.5±0.3	1.8±0.3
Macrovegetation	0.9±0.4	1.4±0.3	1.6±0.3	1.8±0.3	1.9±0.4
Sand + Mud	2.9±0.5	5.1±0.4	6.6±0.5	6.9±0.5	7.4±1.0
Semi-digested food materials	12.0±6.0	26.0±7.5	36.2±8.0	42.0±9.6	49.6±10.8
Algal spores and zygotes	2.6±0.4	2.2±0.5	1.6±0.3	1.5±0.2	1.2±0.3

± = Standard error of mean.

TABLE - IV

Seasonal variations in the gastrosomatic index of G. *chanra*

Months		Baigul Specimens				Months		Nanaksagar Specimens			
		Male	Female	Combined	% of empty guts			Male	Female	Combined	% of empty guts
October	1977	4.7±0.5	3.3±0.2	3.7±0.2	-	January	1978	4.8±0.4	4.2±0.6	4.4±0.2	10.7
November	"	4.8±0.5	4.1±0.2	4.1±0.2	-	February	"	4.5±0.5	3.9±0.4	4.3±0.3	14.3
December	"	5.3±0.6	3.7±0.4	3.9±0.3	-	March	"	4.6±0.4	4.2±0.3	4.4±0.2	-
January	1978	4.0±0.4	3.6±0.3	3.8±0.2	7.7	April	"	5.7±0.5	5.7±0.4	5.7±0.3	-
February	"	4.6±0.4	4.0±0.2	4.2±0.2	11.5	May	"	6.5±0.4	5.6±0.2	5.8±0.2	-
March	"	5.4±0.3	5.0±0.3	5.3±0.2	-	June	"	5.9±0.3	6.6±0.3	6.4±0.3	-
April	"	5.5±0.6	5.5±0.5	5.5±0.3	-	July	"	2.4±0.2	2.6±0.2	2.6±0.1	25.0
May	"	7.2±0.4	7.1±0.3	7.2±0.3	-	August	"	2.3±0.2	2.4±0.2	2.4±0.1	32.1
June	"	2.7±0.2	4.1±0.2	3.7±0.2	11.5	September	"	1.9±0.1	1.9±0.1	1.9±0.1	14.3
July	"	2.1±0.3	3.2±0.2	3.3±0.2	26.9	October	"	2.8±0.3	2.3±0.2	2.4±0.2	-
August	"	2.7±0.3	2.5±0.1	2.6±0.1	30.8	November	"	3.1±0.4	4.9±0.4	4.1±0.2	-
September	"	2.6±0.3	2.7±0.1	2.7±0.1	11.5	December	"	4.4±0.2	3.2±0.2	3.7±0.1	3.6

± = Standard error of mean.

TABLE V

Seasonal variations in the gastrosomatic index in different size groups of *G. giuris*.

Size groups (mm)	Gastrosomatic index 1977 Oct	Nov	Dec	Months Jan	Feb	Mar	Apr	May	Jun	1978 Jul	Aug	Sep	Mean	% of empty gut
							BAIGUL SPECIMENS							
I (40– 73)	6.4	6.8	5.7	5.3	4.5	5.6	–	–	–	–	–	–	5.7±0.2	–
II (74–107)	4.4	5.0	5.6	6.0	3.4	7.3	7.2	7.0	5.3	3.3	3.6	2.6	5.2±0.5	7.7
III (108–141)	5.0	5.5	3.7	3.4	3.3	5.2	6.6	6.7	5.4	3.5	3.3	3.6	4.6±0.4	34.6
IV (142–175)	3.5	3.8	3.4	3.3	2.9	3.6	3.7	3.9	3.6	2.7	2.4	2.7	3.3±0.2	46.2
V (176–215)	2.7	3.9	3.5	3.4	3.2	4.7	4.0	5.2	4.1	4.3	2.7	2.7	3.7±0.2	11.5

Size groups (mm)	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	% of empty gut
							HUSSAINSAGAR SPECIMENS							
I (40– 73)	5.0	7.0	6.4	7.6	7.4	7.5	–	–	–	1.9	2.3	2.9	5.3±0.5	–
II (74–107)	4.2	6.2	6.2	7.5	7.2	7.2	2.4	2.5	2.7	3.1	4.1	4.3	4.8±0.2	17.8
III (108–141)	4.3	3.7	3.8	5.4	6.4	5.9	2.7	1.7	1.8	2.4	4.4	3.0	3.8±0.4	21.5
IV (142–175)	2.8	2.8	3.0	4.3	4.8	3.5	1.3	1.6	1.8	1.8	2.8	3.3	2.8±0.3	32.1
V (176–215)	2.3	2.3	2.9	3.4	4.5	5.5	1.8	1.9	2.2	3.6	2.2	3.6	3.0±0.3	23.6

± = Standard error of mean

TABLE VI

Seasonal variations in the gastrosomatic index in *G. chapra* in different stage of maturity.

Months	Year	I Stage		II Stage		III Stage		IV Stage		V Stage	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
						BAIGUL SPECIMENS					
October	1977	5.0	4.7	3.9	3.8	-	-	-	-	-	-
November	"	5.4	3.5	4.2	5.2	-	-	-	-	-	-
December	"	6.3	6.4	3.6	2.6	-	-	-	-	-	-
January	1978	5.7	5.3	2.9	2.9	-	-	-	-	-	-
February	"	4.9	5.6	2.6	3.6	-	-	-	-	-	-
March	"	6.1	7.4	4.5	4.7	4.2	4.6	-	4.3	-	-
April	"	5.8	7.8	6.1	4.9	4.5	5.8	5.8	4.9	-	-
May	"	8.3	8.7	8.0	6.3	7.1	7.1	5.3	6.6	-	-
June	"	-	5.1	-	-	2.7	4.3	2.7	3.8	-	-
July	"	-	-	-	-	-	3.2	3.7	3.6	3.3	3.2
August	"	-	-	-	-	-	-	-	1.8	2.7	2.6
September	"	-	-	3.6	3.7	-	-	-	3.3	3.0	2.0
Mean		5.9±0.4	6.1±0.6	4.4±0.6	4.2±0.4	4.6±0.8	5.0±0.7	4.4±0.7	4.1±0.5	3.0±0.3	2.6±0.3
						NANAKSAGAR SPECIMENS					
January	1978	4.9	4.2	4.0	4.1	-	-	-	-	-	-
February	"	5.3	6.2	3.2	3.0	-	-	-	-	-	-
March	"	5.2	6.0	2.8	3.7	-	3.0	-	-	-	-
April	"	6.5	7.3	3.9	4.3	4.5	4.7	-	-	-	-
May	"	7.3	7.1	6.5	7.1	6.3	4.7	4.7	4.8	-	-
June	"	-	-	-	-	5.2	7.8	6.3	5.8	-	-
July	"	-	-	-	-	-	-	2.5	4.4	2.4	2.4
August	"	-	-	-	-	-	-	-	-	2.3	2.4
September	"	-	-	1.9	2.2	-	-	-	1.4	1.7	1.8
October	"	2.5	2.5	3.3	2.1	-	-	-	2.6	-	-
November	"	3.5	4.0	2.6	2.6	-	-	-	-	-	-
December	"	3.35	3.4	3.4	3.2	-	-	-	-	-	-
Mean		4.8±0.6	5.1±0.6	3.5±0.4	3.6±0.5	5.3±0.6	5.1±1.0	4.5±1.1	3.8±0.8	2.1±0.2	2.2±0.2

± = Standard error of mean

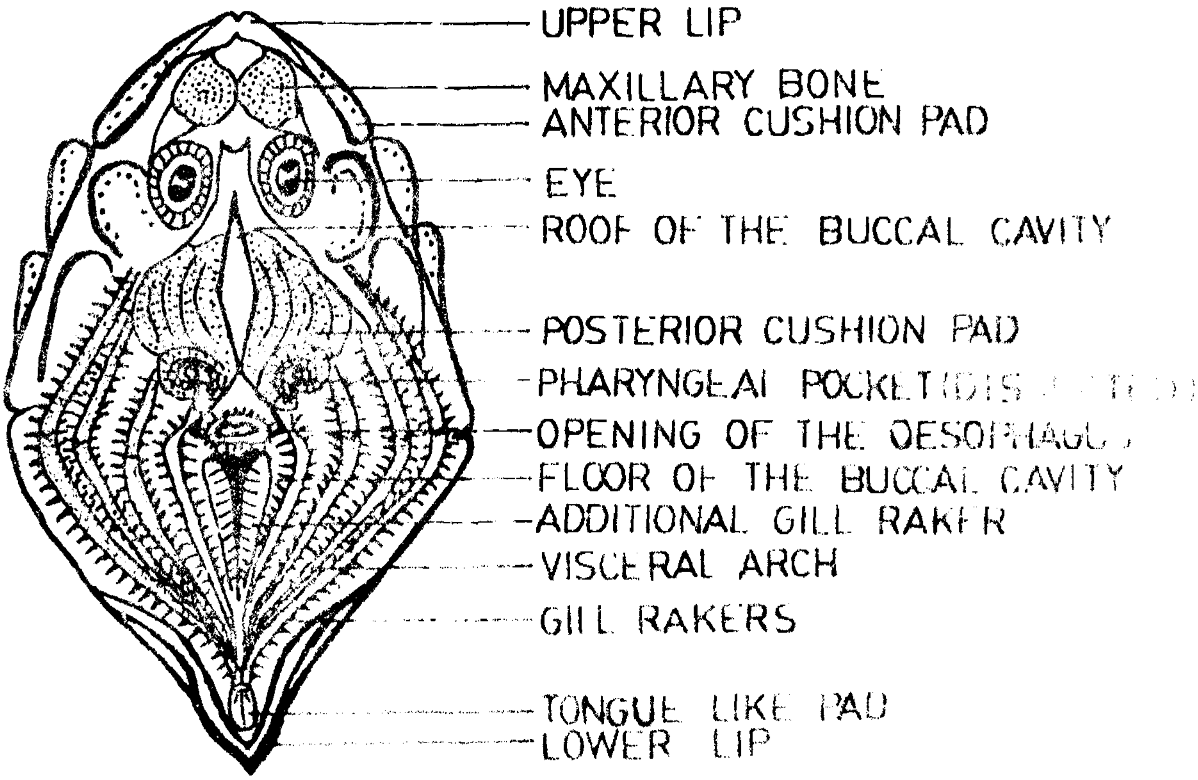
TABLE VII

Percentage composition of planktons in the gut (ri) and environment (pi) of [illegible] and the electivity index (E).

Food organisms	BAIGUL ri	BAIGUL pi	BAIGUL E	NANAKSAGAR ri	NANAKSAGAR pi	NANAKSAGAR E
GREEN ALGAE						
Tetraedron	0.2	0.4	-0.333	0.2	0.5	-0.429
Pediastrum	0.8	0.4	-0.333	0.7	0.6	+0.077
Botryococcus	6.2	4.5	+0.131	7.3	4.5	+0.237
Ankistrodesmus	0.9	0.5	+0.286	0.9	0.6	+0.200
Scenedesmus	2.2	2.2	+0	0.9	0.6	+0.200
Oedogonium	0.2	0.6	-0.500	0.5	1.0	-0.333
Crucigenia	1.2	0.8	+0.200	0.5	0.4	+0.111
Phacus	0.2	0.1	+0.333	3.4	2.5	+0.153
Tetraedriella	0.1	0.2	-0.333	0.5	1.0	-0.333
Glenodinium	23.0	10.1	+0.390	10.7	12.2	+0.255
Zygnema	11.2	6.7	+0.251	24.4	15.1	+0.235
Dinobryon	0.4	0.4	+0	2.5	1.3	+0.316
Euglena	0.2	0.1	+0.333	1.5	0.9	+0.250
Selenastrum	0.2	0.6	-0.500	-	-	-
Coelastrum	0.2	0.7	-0.556	-	-	-
Kirchneriella	0.2	0.6	-0.500	-	-	-
Oocystis	0.2	0.5	-0.429	-	-	-
Protococcus	0.5	0.4	+0.111	-	-	-
Arthrodesmus	0.1	0.2	-0.333	-	-	-
ALGAL SPORES & ZYGOTES	1.4	25.6	-0.898	2.5	26.4	-0.827
BLUE GREEN ALGAE						
Oscillatoria	0.7	5.7	-0.781	0.5	4.2	-0.787
Anabaena	0.2	3.4	-0.889	0.2	4.0	-0.905
DESMIDS						
Closterium	3.3	1.9	+0.269	2.7	2.3	+0.080
Cosmarium	2.1	1.9	+0.050	2.6	2.1	+0.106
Staurastrum	0.4	0.3	+0.143	2.0	1.7	+0.081
Gonatozygon	0.1	0.6	-0.714	0.2	1.2	-0.741
Mesotaenium	2.4	4.7	-0.324	-	-	-

Food organisms	BAIGUL ri	BAIGUL pi	BAIGUL E	NANAKSAGAR ri	NANAKSAGAR pi	NANAKSAGAR E
DIATOMS						
Cocconeis	0.7	0.6	+0.077	0.3	0.2	+0.200
Rhopalodia	2.7	1.6	+0.256	2.0	1.0	+0.333
Cyclotella	1.6	1.5	+0.032	0.4	0.3	+0.143
Melosira	5.1	3.5	+0.186	1.7	1.0	+0.259
Diatoma	3.3	2.2	+0.200	2.2	1.3	+0.257
Gyrosigma	0.2	1.5	-0.765	0.1	0.4	-0.600
Nitzschia	4.4	1.9	+0.397	1.8	1.3	+0.161
Synedra	7.3	2.7	+0.460	1.6	1.0	+0.231
Navicula	3.1	1.5	+0.348	0.9	0.6	+0.200
Epithemia	2.2	1.2	+0.294	1.2	0.9	+0.143
Amphora	0.6	0.5	+0.091	0.4	0.3	+0.143
Surirella	0.2	1.0	-0.667	0.3	0.2	+0.200
Fragilaria	0.7	0.5	+0.167	0.9	0.6	+0.200
Tabellaria	0.1	0.7	-0.750	-	-	-
Eunotia	0.6	0.5	+0.091	-	-	-
Cymatopleura	-	-	-	0.4	0.3	+0.143
MICRO CRUSTACEANS						
Bosmina	0.6	0.4	+0.200	0.7	0.4	+0.273
Daphnia	0.5	0.3	+0.250	0.8	0.5	+0.231
Simocephalus	0.7	0.4	+0.273	1.5	0.9	+0.250
Macrothrix	0.4	0.3	+0.143	2.0	1.2	+0.250
[illegible]	0.3	0.6	-0.333	0.5	0.4	+0.111
[illegible]	0.6	0.5	+0.091	1.5	0.6	+0.368
[illegible]	-	-	-	0.2	0.1	+0.333
[illegible]	-	-	-	0.1	0.3	-0.500
[illegible]	-	-	-	0.2	0.1	+0.333
ROTIFERS						
Keratella	3.1	1.9	+0.240	3.5	1.9	+0.296
Brachionus	1.7	1.6	+0.030	1.2	0.8	+0.200
Trichocerca	0.4	0.9	-0.385	0.1	0.3	-0.500

Fig. 1. Bucco-pharyngeal cavity of *O. channa*.



UPPER LIP
MAXILLARY BONE
ANTERIOR CUSHION PAD
EYE
ROOF OF THE BUCCAL CAVITY
POSTERIOR CUSHION PAD
PHARYNGEAL POCKET
OPENING OF THE OESOPHAGU
FLOOR OF THE BUCCAL CAVITY
ADDITIONAL GILL RAKER
VISCERAL ARCH
GILL RAKERS
TONGUE LIKE PAD
LOWER LIP

Fig. 2. Alimentary canal of *G. chazra*.

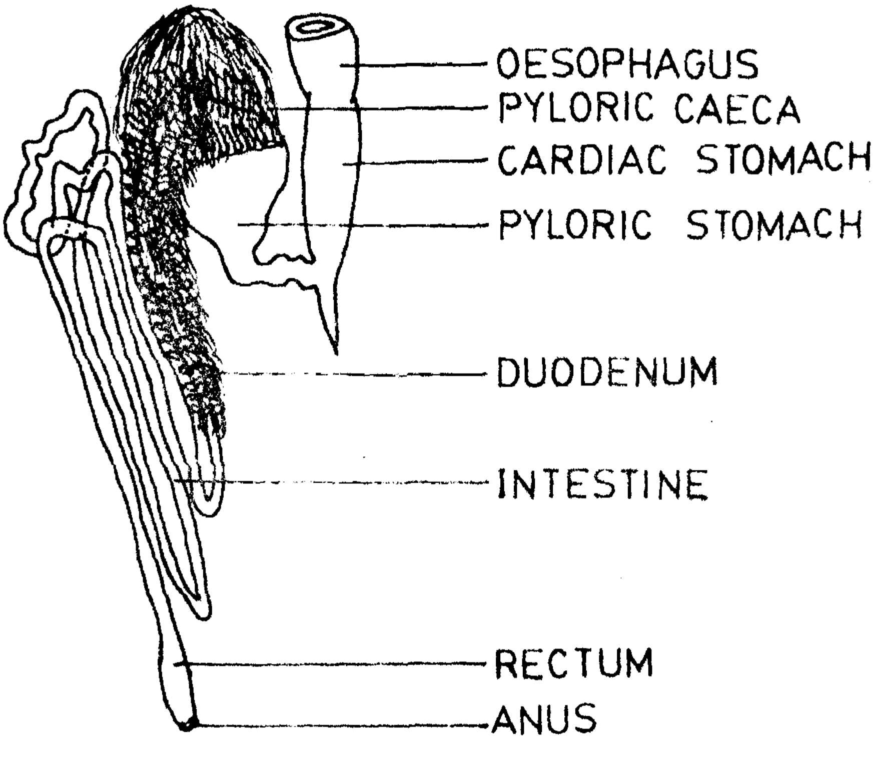
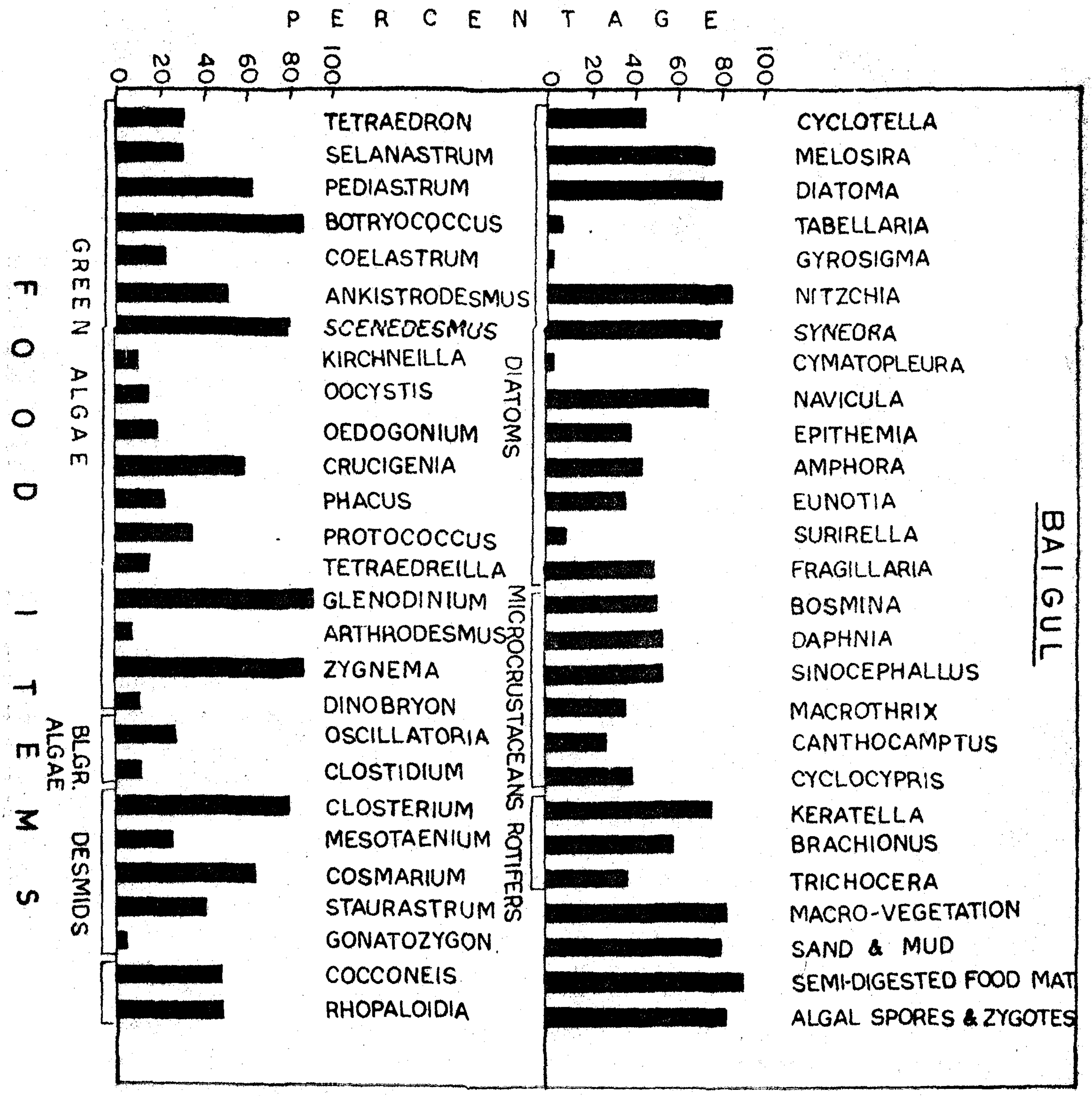

OESOPHAGUS
PYLORIC CAECA
CARDIAC STOMACH
PYLORIC STOMACH
DUODENUM
INTESTINE
RECTUM
ANUS

Fig. 3. Frequency of occurrence (%) of food items in the gut of G. chapra (Baigul).



PERCENTAGE
0
20
40
60
80
100
FOOD ITEMS
GREEN ALGAE
BLGR. ALGAE
DESMIDS
DIATOMS
MICROCRUSTACEANS
ROTIFERS
BAIGUL
TETRAEDRON
SELANASTRUM
PEDIASTRUM
BOTRYOCOCCUS
COELASTRUM
ANKISTRODESMUS
SCENEDESMUS
KIRCHNEILLA
OOCYSTIS
OEDOGONIUM
CRUCIGENIA
PHACUS
PROTOCOCCUS
TETRAEDREILLA
GLENODINIUM
ARTHRODESMUS
ZYGNEMA
DINOBRYON
OSCILLATORIA
CLOSTIDIUM
CLOSTERIUM
MESOTAENIUM
COSMARIUM
STAURASTRUM
GONATOZYGON
COCCONEIS
RHOPALOIDIA
CYCLOTELLA
MELOSIRA
DIATOMA
TABELLARIA
GYROSIGMA
NITZCHIA
SYNEDRA
CYMATOPLEURA
NAVICULA
EPITHEMIA
AMPHORA
EUNOTIA
SURIRELLA
FRAGILLARIA
BOSMINA
DAPHNIA
SINOCEPHALLUS
MACROTHRIX
CANTHOCAMPTUS
CYCLOCYPRIS
KERATELLA
BRACHIONUS
TRICHOCERA
MACRO-VEGETATION
SAND & MUD
SEMI-DIGESTED FOOD MAT
ALGAL SPORES & ZYGOTES

Fig. 4. Relative abundance of the food items in the gut of *G. chapra* (Saigul).

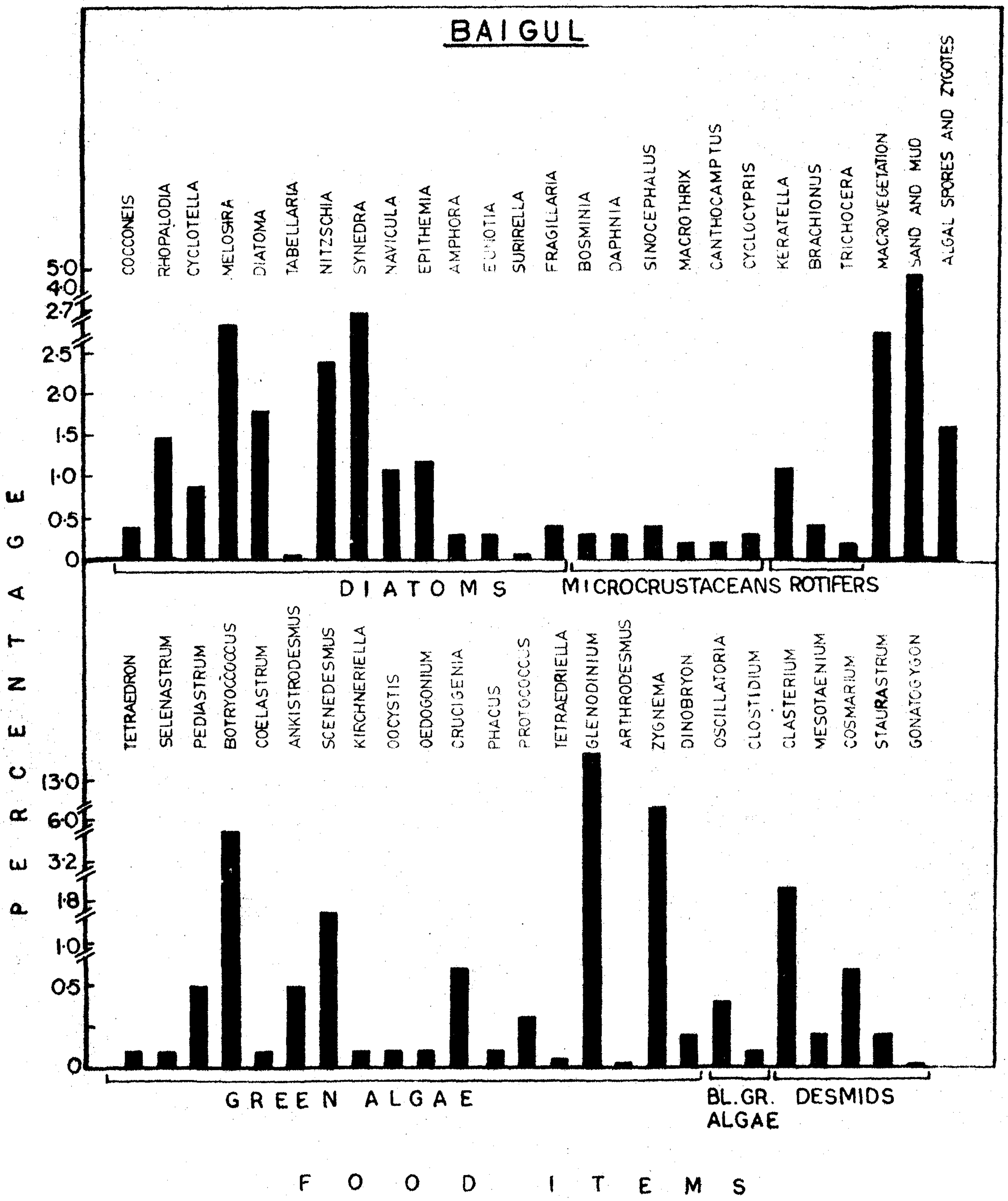
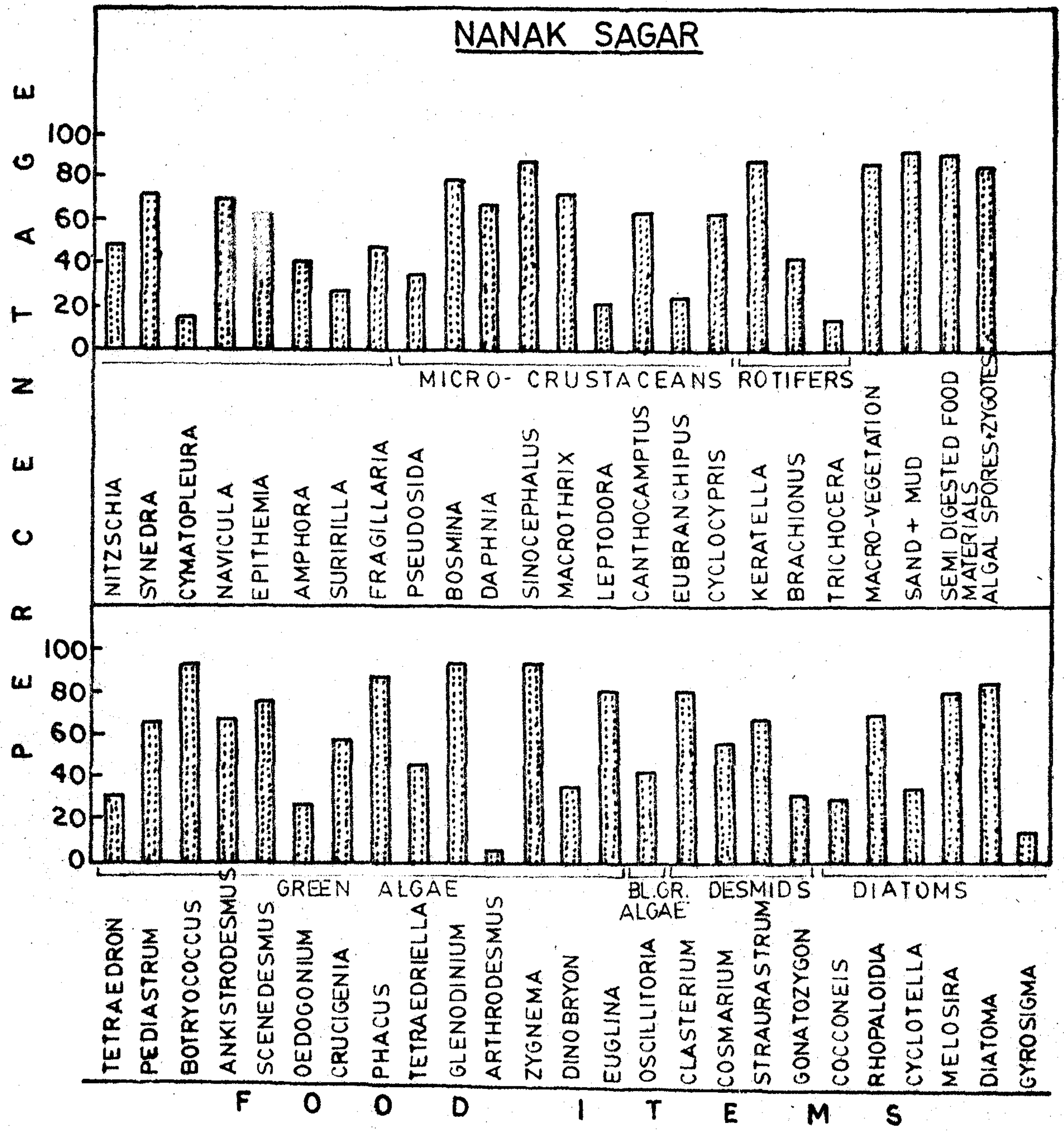

BAIGUL
PERCENTAGE
COCCONEIS
RHOPALODIA
CYCLOTELLA
MELOSIRA
DIATOMA
TABELLARIA
NITZSCHIA
SYNEDRA
NAVICULA
EPITHEMIA
AMPHORA
EUNOTIA
SURIRELLA
FRAGILLARIA
BOSMINIA
DAPHNIA
SINOCEPHALUS
MACROTHRIX
CANTHOCAMPTUS
CYCLOCYPRIS
KERATELLA
BRACHIONUS
TRICHOCERA
MACROVEGETATION
SAND AND MUD
ALGAL SPORES AND ZYGOTES
5·0
4·0
2·7
2·5
2·0
1·5
1·0
0·5
0
DIATOMS
MICROCRUSTACEANS
ROTIFERS
TETRAEDRON
SELENASTRUM
PEDIASTRUM
BOTRYOCOCCUS
COELASTRUM
ANKISTRODESMUS
SCENEDESMUS
KIRCHNERIELLA
OOCYSTIS
OEDOGONIUM
CRUCIGENIA
PHACUS
PROTOCOCCUS
TETRAEDRIELLA
GLENODINIUM
ARTHRODESMUS
ZYGNEMA
DINOBRYON
OSCILLATORIA
CLOSTIDIUM
CLASTERIUM
MESOTAENIUM
COSMARIUM
STAURASTRUM
GONATOGYGON
13·0
6·0
3·2
1·8
1·0
0·5
0
GREEN ALGAE
BL. GR. ALGAE
DESMIDS
FOOD ITEMS

Fig. 5. Frequency of occurrence (%) of food items in the gut of *G. chapra* (Nanaksagar).



NANAK SAGAR
PERCENTAGE
0
20
40
60
80
100
NITZSCHIA
SYNEDRA
CYMATOPLEURA
NAVICULA
EPITHEMIA
AMPHORA
SURIRILLA
FRAGILLARIA
PSEUDOSIDA
BOSMINA
DAPHNIA
SINOCEPHALUS
MACROTHRIX
LEPTODORA
CANTHOCAMPTUS
EUBRANCHIPUS
CYCLOCYPRIS
KERATELLA
BRACHIONUS
TRICHOCERA
MACRO-VEGETATION
SAND + MUD
SEMI DIGESTED FOOD MATERIALS
ALGAL SPORES+ZYGOTES
MICRO- CRUSTACEANS
ROTIFERS
TETRAEDRON
PEDIASTRUM
BOTRYOCOCCUS
ANKISTRODESMUS
SCENEDESMUS
OEDOGONIUM
CRUCIGENIA
PHACUS
TETRAEDRIELLA
GLENODINIUM
ARTHRODESMUS
ZYGNEMA
DINOBRYON
EUGLINA
OSCILLITORIA
CLASTERIUM
COSMARIUM
STRAURASTRUM
GONATOZYGON
COCCONEIS
RHOPALOIDIA
CYCLOTELLA
MELOSIRA
DIATOMA
GYROSIGMA
GREEN ALGAE
BL.GR. ALGAE
DESMIDS
DIATOMS
FOOD ITEMS

Fig. 6. Relative abundance of the food items in the gut of *G. chapra* (Nanaksagar).

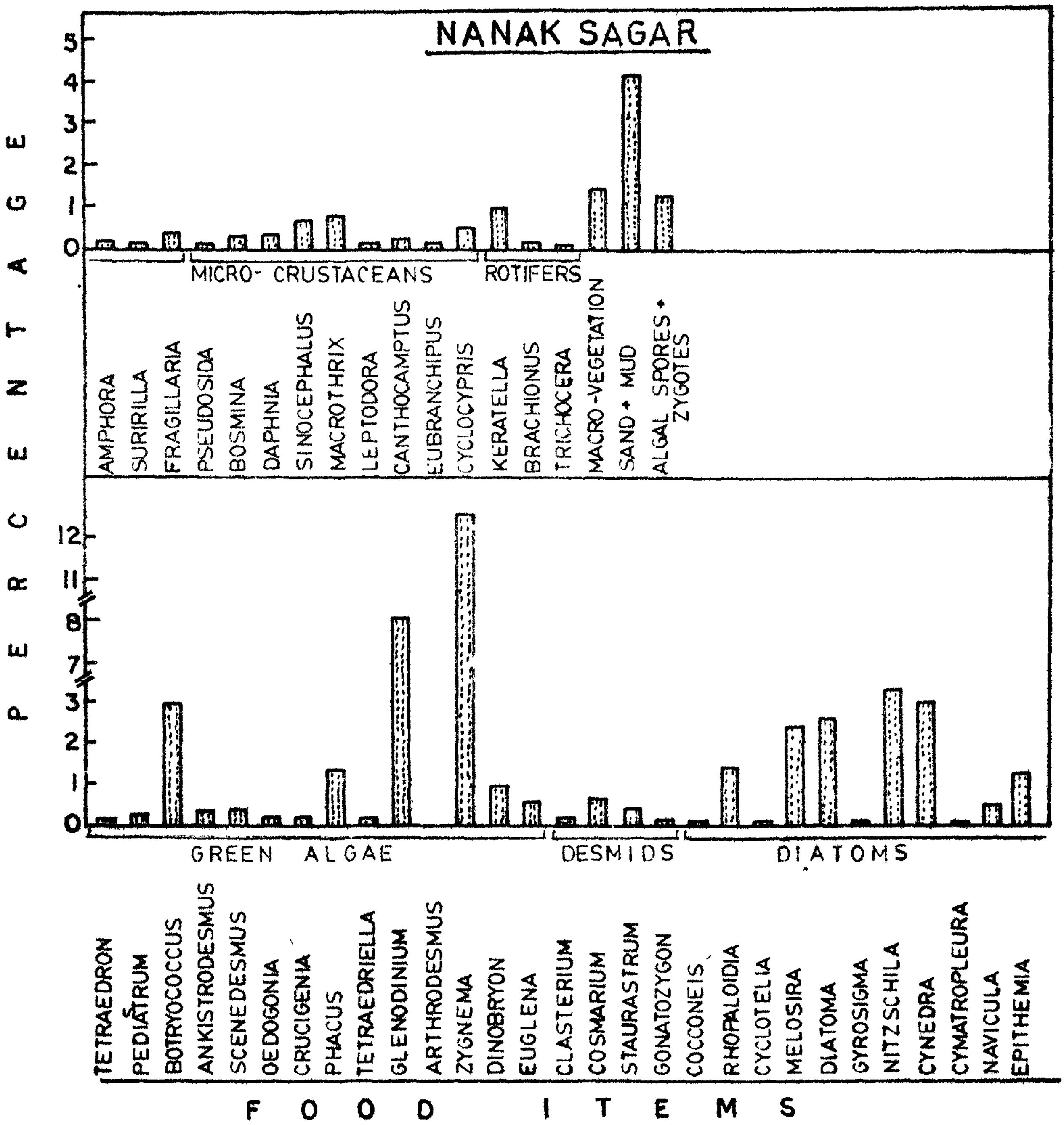
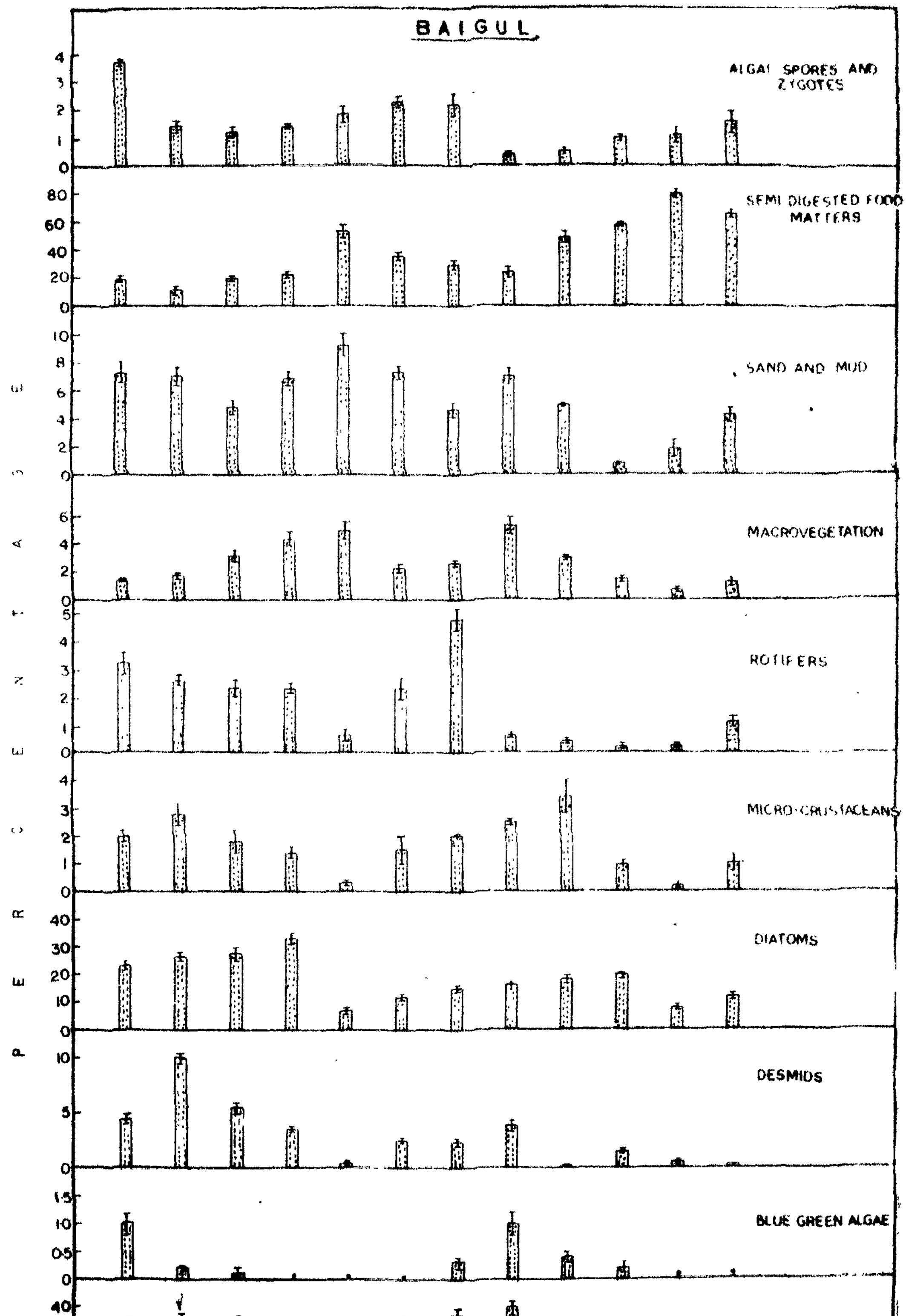
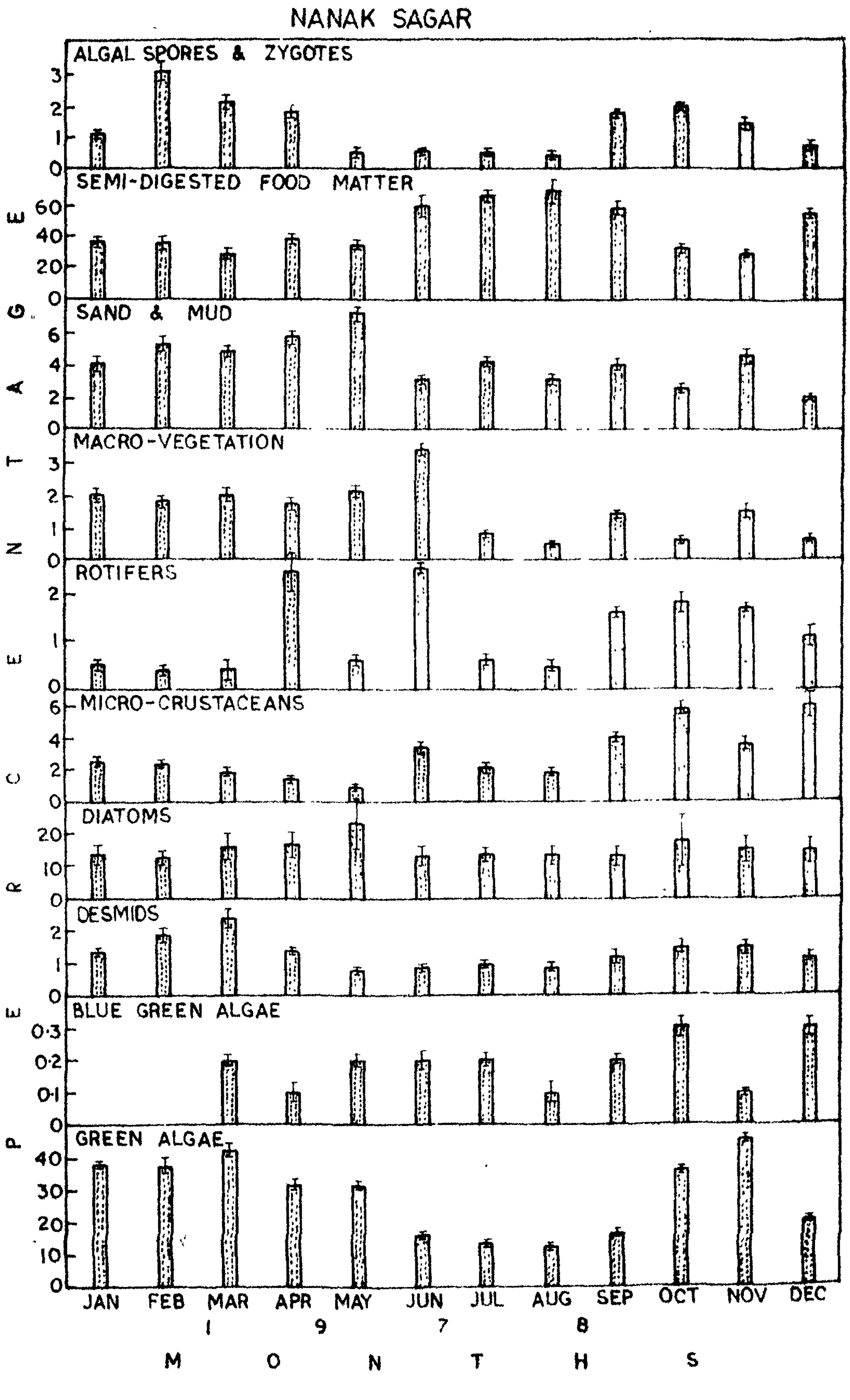

NANAK SAGAR
PERCENTAGE
MICRO- CRUSTACEANS
ROTIFERS
AMPHORA
SURIRILLA
FRAGILLARIA
PSEUDOSIDA
BOSMINA
DAPHNIA
SINOCEPHALUS
MACROTHRIX
LEPTODORA
CANTHOCAMPTUS
EUBRANCHIPUS
CYCLOCYPRIS
KERATELLA
BRACHIONUS
TRICHOCERA
MACRO-VEGETATION
SAND + MUD
ALGAL SPORES + ZYGOTES
GREEN ALGAE
DESMIDS
DIATOMS
TETRAEDRON
PEDIATRUM
BOTRYOCOCCUS
ANKISTRODESMUS
SCENEDESMUS
OEDOGONIA
CRUCIGENIA
PHACUS
TETRAEDRIELLA
GLENODINIUM
ARTHRODESMUS
ZYGNEMA
DINOBRYON
EUGLENA
CLASTERIUM
COSMARIUM
STAURASTRUM
GONATOZYGON
COCCONEIS
RHOPALOIDIA
CYCLOTELIA
MELOSIRA
DIATOMA
GYROSIGMA
NITZSCHILA
CYNEDRA
CYMATROPLEURA
NAVICULA
EPITHEMIA
FOOD ITEMS

Fig. 7. Relative abundance of the food items in the gut of *G. chapra* in various months (Baigul).



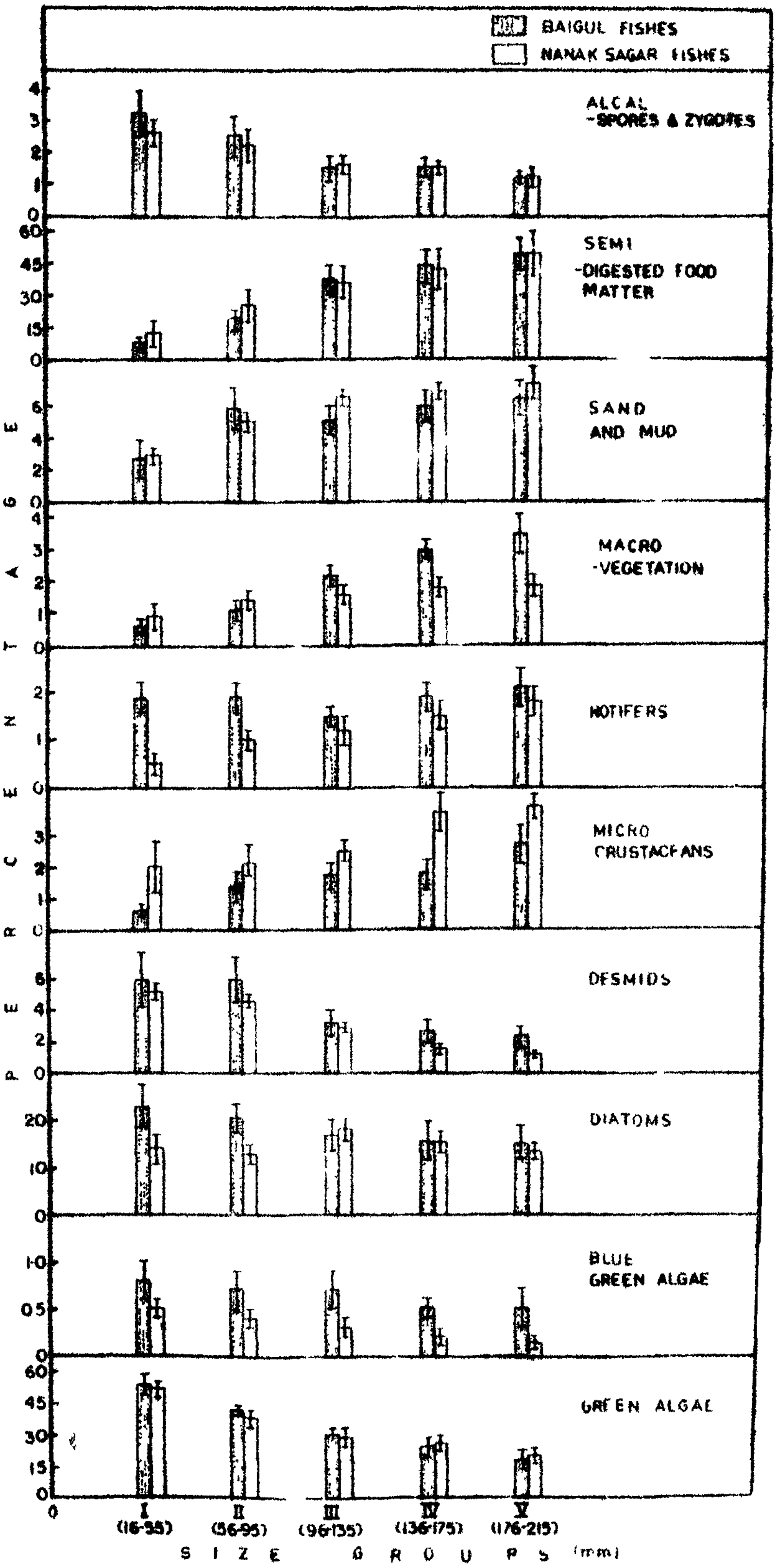
BAIGUL
ALGAL SPORES AND ZYGOTES
SEMI DIGESTED FOOD MATTERS
SAND AND MUD
MACROVEGETATION
ROTIFERS
MICRO-CRUSTACEANS
DIATOMS
DESMIDS
BLUE GREEN ALGAE
GREEN ALGAE
P E R C E N T A G E
OCT 1977
NOV
DEC
JAN 1978
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
M O N T H S

Fig. 8. Relative abundance of the food items in the gut of *G. chapra* in various months (Manaksagar).



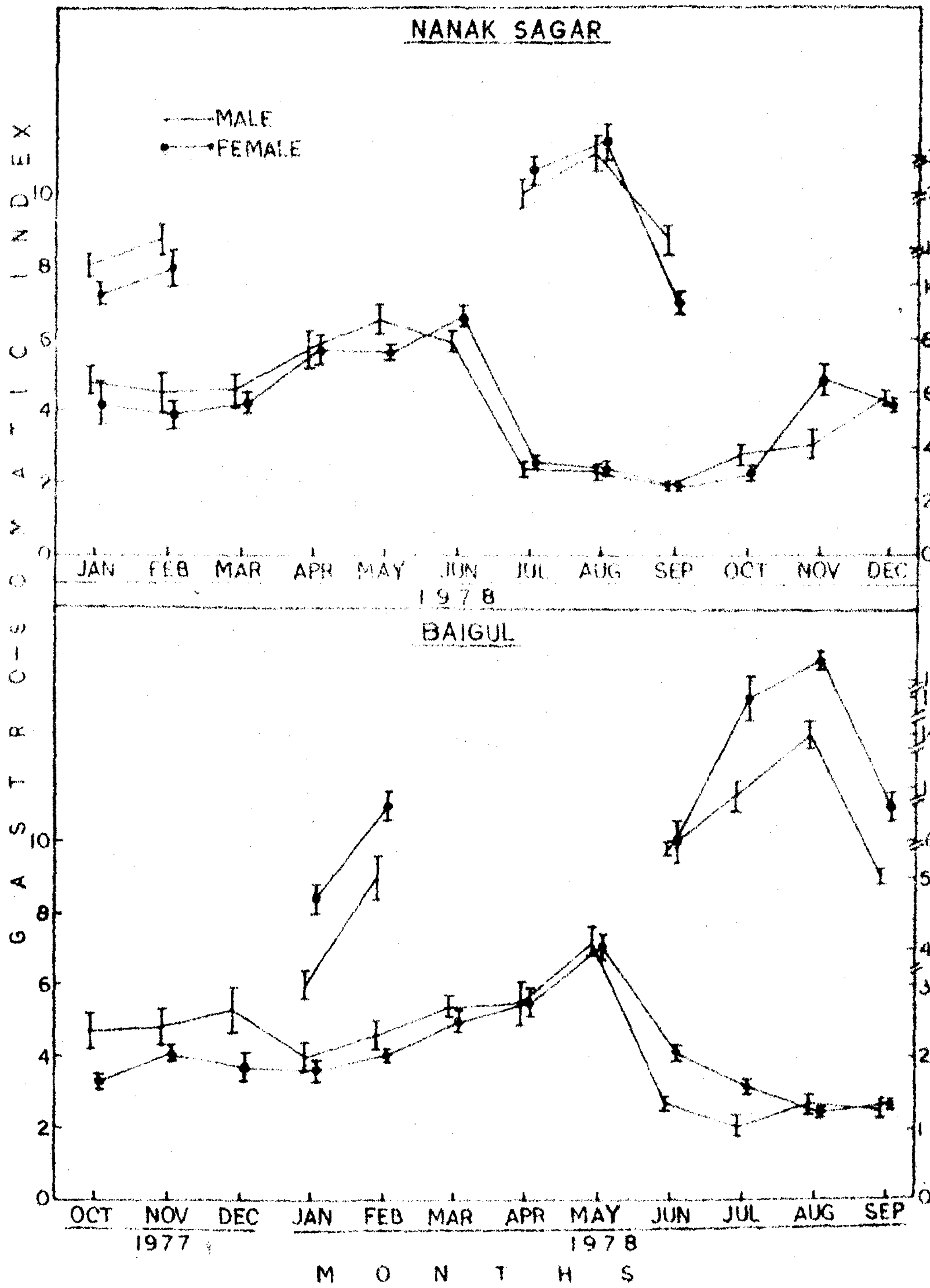
NANAK SAGAR
ALGAL SPORES & ZYGOTES
SEMI-DIGESTED FOOD MATTER
SAND & MUD
MACRO-VEGETATION
ROTIFERS
MICRO-CRUSTACEANS
DIATOMS
DESMIDS
BLUE GREEN ALGAE
GREEN ALGAE
PERCENTAGE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1978
MONTHS

Fig. 9. Percentage composition of the major groups of food items in the diet of _G. shanga_ of different size groups.



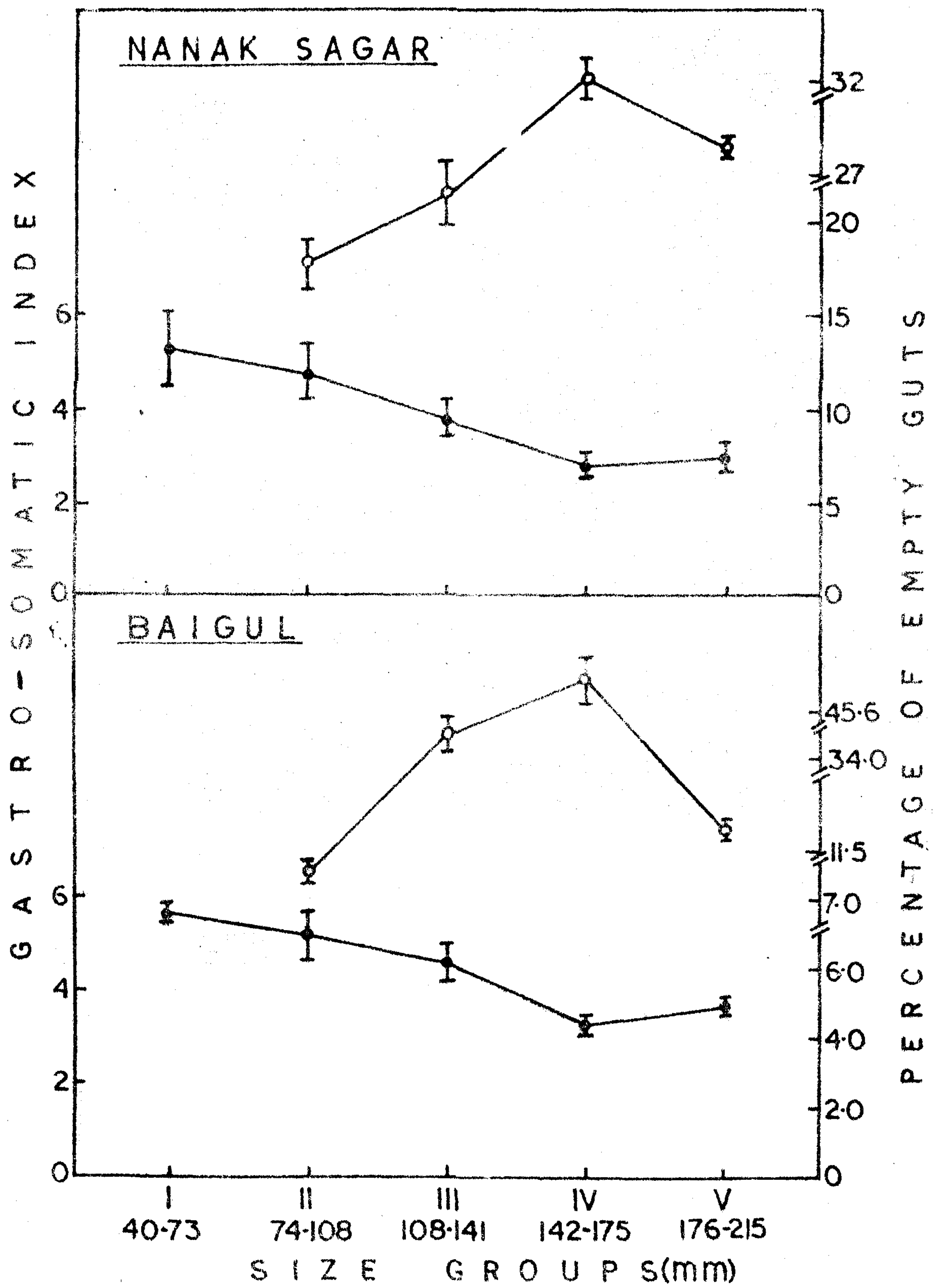
BAIGUL FISHES
NANAK SAGAR FISHES
ALGAL -SPORES & ZYGOTES
SEMI -DIGESTED FOOD MATTER
SAND AND MUD
MACRO -VEGETATION
ROTIFERS
MICRO CRUSTACEANS
DESMIDS
DIATOMS
BLUE GREEN ALGAE
GREEN ALGAE
PERCENTAGE
I (16-55)
II (56-95)
III (96-135)
IV (136-175)
V (176-215)
SIZE GROUPS (mm)

Fig. 10. Seasonal variation in the gastrosomatic index and percentage of empty guts of *G. chanma*.



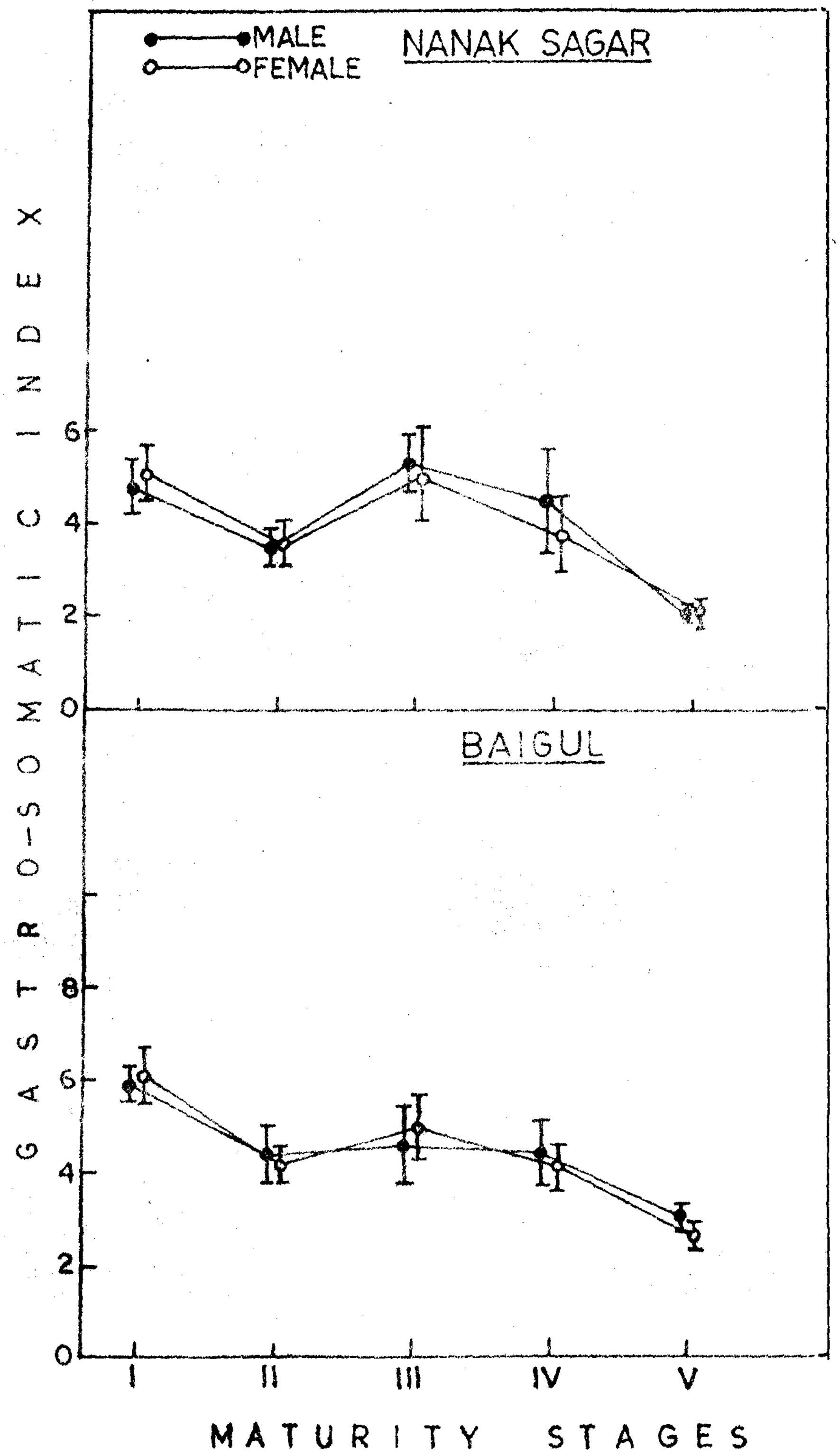
NANAK SAGAR
MALE
FEMALE
GASTRO-SOMATIC INDEX
EMPTY GUT PERCENTAGE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1978
BAIGUL
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
1977
1978
MONTHS

Fig. 11. Gastrosomatic index and percentage of empty guts in different size groups of *G. chapra*.



NANAK SAGAR
BAIGUL
GASTRO-SOMATIC INDEX
PERCENTAGE OF EMPTY GUTS
0
2
4
6
0
5
10
15
20
27
32
45·6
34·0
11·5
7·0
6·0
4·0
2·0
I
40-73
II
74-108
III
108-141
IV
142-175
V
176-215
SIZE GROUPS(mm)

Fig. 12. Changes in gastrosomatic index of G. chapra in relation to maturation.



MALE
FEMALE
NANAK SAGAR
BAIGUL
GASTRO-SOMATIC INDEX
0
2
4
6
8
I
II
III
IV
V
MATURITY STAGES

CHAPTER II

AGE AND GROWTH

I N T R O D U C T I O N

Data pertaining to age of a fish are basically important in life history studies including growth rate, onset of maturity, spawning time, longevity and are also used in fishery investigations to yield information on age composition of catch and fluctuations in abundance of the various year classes (Jensen, 1971). Together with such observations, studies on growth of fish are of paramount significance in all fisheries research programmes and particularly in regulation, management and rational exploitation of the populations of commercially important species. While there is no controversy vis-a-vis the use of annual marks on the scales, otalith, opercular bone, spines and rays in age and growth studies on temperate fishes, the issue is controversial as far as the tropical ichthyofauna is concerned. Workers including Pantulu (1961), Tesch(1968) and Murty (1975) expressed reservations and scepticism on reliability of zonations on hard parts of the body of the fish from tropical environments, other investigators (Jhingran, 1971; Qasim & Bhatt, 1964, 1966; Bhatt, 1970; Khan and Siddiqi, 1973) have successfully applied the technique in several species of murrels and major carps from freshwaters of Northern India. Qasim (1973) in an admirable review of the problem suggested flexibility from rigid attitudes and emphasized the need for more productive work, rethinking and revision with reference to tropical fishes. An attempt was made by the author to study the age and growth of G. chapra from Baigul and Nanaksagar reservoirs in Western Uttar Pradesh with the determination to present data on these aspects of the biology of this species and to set at rest some of the doubtful concepts, many of which are only hypothetical.

MATERIALS AND METHODS

Specimens of G. chapra numbering 414 and 413 were collected from Baigul and Nanaksagar reservoirs, respectively, over a period of twelve months. Their total length, body weight and sex were recorded. Eight to ten scales of each individual were removed from below the place of origin of dorsal fin and lateral line as per the universal practice, washed thoroughly with water to remove mucous and other adhering substances, dried on absorbent paper and placed separately in marked envelops for future observations. Being small and translucent the scales were examined under microscope equipped with occular micrometer. Length of scale from focus to its outer edge and distance from focus to each annulus were measured. Occular readings were converted into millimeter. Number of completed annuli was counted for age determination. In the present study observations on each scale of an individual tallied with independent readings on the remaining four or five scale samples of each specimen. Abnormal scales and those with incomplete rings were rejected for age and growth study. However, their number and percentage were recorded. For an idea of probable period of ring formation, margins of scales were looked for throughout the year and percentage of scales with newly formed marginal rings in different months was calculated.

The body-scale length relationship was established by regression equation following the standard method of least squares. Length of the fish at the time of annulus formation was back calculated for each specimen separately by using Lee's direct proportion formula as suggested by Rounsefell & Everhart (1953):

$$L_1 = \frac{L \times S_1}{S}$$

where 'L_1' is the length of the fish at the time of annulus formation, 'L' is the present length of the fish (at the time of capture), 'S' is the total length of the scale measured from focus to outer margin of the scale and 'S_1' is the distance between the focus and each annulus.

From the data on length at various years of life, annual growth increments as well as changes in growth rate with age were found out. The relative growth (in percentage) was determined by the usual formula :

$$\text{Relative growth} = 100 - \frac{\underset{(mm)}{\text{Total length}} - \underset{(mm)}{\text{Growth increment}}}{\underset{(mm)}{\text{Total length}}} \times 100$$

Specific (instantaneous) growth rate (g) was computed separately for each age group by the formula (Ball &Jones, 1960):

$$G = \frac{\text{Log}_e L_2 - \text{Log}_e L_1}{(T_2 - T_1)} \times 100$$

where 'L_1' and 'L_2' are the lengths (mm) at the times 'T_1' (begining of each year of life) and 'T_2' (end of each year of life). 'G' gives percentage increase per unit time (one year). Log_e is the base of neparian logarithm. The above equation in its simpler form becomes:

$$G = \frac{\text{Log } L_2 - \text{Log } L_1}{\text{Log}_e} \times 100$$

The abbreviations in this formula have their usual values.

Von Bertalanffy's growth equation as described by Beverton & Holt (1957) was fitted to length at each age data of Baigul and Manaksagar fish:

$$lt = l\alpha \left[1-e^{-K(t-t_0)} \right]$$

Where, lt = length at age t; $l\alpha$ = asymptotic length; e = base of the neperian (natural) logarithm; K = coefficient of catabolism; t = age of fish; t_o = arbitrary origin of the growth curve. To fit this growth equation to the length at age data, the following formula developed by Ford (1933) Walford (1946) of plotting 'l_{t+1}' against 'l_t' was applied:

$$l_{t+1} = L\alpha(1 - e^{-K}) + l_t e^{-K}$$

Where, l_t and l_{t+1} are the lengths of the fish at age 't' and '$t+1$', respectively. A straight line relationship appeared with resultant slope and the point where this line cuts the bisector represents the asymptotic length '$l\alpha$'.

The value of 'K' is estimated as:

$$K = (e^{-k}) \text{ or } K = -\text{Log } k/\log_e$$

For deriving 'k' the equation used is:

$$k = L\alpha - (L\alpha - y) / L\alpha$$

Where $(L\alpha - y)$ is the distance between the asymptotic length and the point where the slope line cuts the Y-axis. 't_o' of the Beverton-Holt relation was evaluated according to Ricker (1958):

$$\log_e (L\alpha - l_t) = (\log_e l\alpha - Kt_o) - Kt, \text{ which is as good as:}$$

$$t_o = (\log_e l\alpha + Kt_o) - \log_e l\alpha / K$$

Value of $\log_e (l\alpha - lt)$ was plotted against corresponding ages and the resultant regression line was observed to have a slope of '$-K$' and an intercept of $\log_e l\alpha + Kt_0$.

Results obtained through Von Bertalanffy formula were compared with the values derived empirically by length-weight regression equation. Mean lengths of various age groups in each month were determined for elaborating the seasonal trend in the growth of the fish.

O B S E R V A T I O N S

Scales of G. chapra [redacted] are small in size and typical cycloid type, with focus near the center, surrounded by numerous ringular or crescentric and closely aposed circuli. Circuli are the surface ridges mostly continuous but often discontinuous and homogneous with the scale framework. Radii may be absent but if present, few in number, transversely arranged, complete or incomplete. Annuli are almost transparent grooves in the scale possibly resulting from temporary cessation of circuli formation. These grooves run parallel with the ridges. In addition to these true annuli, false rings are also seen in some individuals but they are incomplete or irregular. Such marks are disregarded in georontological studies.

Abnormal scales occurred in about 20% of the observed cases. These scales were asymmetrical, dome-shaped, triangular, or quadrangular, in the form of unusual grooves which in no way looked like annuli.

The authenticity of annuli in the scale of _G. chapra_ as yearmarks and their use in age and growth studies is unsceptically vindicated by results which conform to the universal criteria: 1) increase in the number of annuli was accompanied by increase in size of the fish, emphasizing that annuli in the scales are not formed haphazardly but systematically as the fish grows, 2) calculated data on growth characteristics closely agrees with the data obtained through actual observations of the fish. Little discrepancy existed between length of fish of two or more years of age back calculated at the first or succeeding years of life using direct proportion method, and the values derived through Von Bertalanffy's growth equation. Each of this set of empirically obtained lengths strikingly approximates the length of specimens of each age group sampled from the reservoirs. There can be no better proof in support of the validity of annuli.

<u>Ring formation</u>:

A newly formed ring lies towards the periphery of the scale around its entire margin. The first marginal ring is laid down sometimes between March and June. The percentages of fish carrying this ring were 31, 61.3, 43.4 and 28.3 in the months of March, April, May and June, respectively whereas in fish which are in their 2, 3, 4 and 5 years of life, the monthly percentage with marginal ring was 47.4 (April), 58.3 (May) and 63.3 (June). By resumption of circuli formation (the way a scale grows), the marginal annulus get shifted f more inward. Interestingly, the distance between annuli was seen in decreasing order when measured from focus towards the outer perimeter i.e., the distance between any two older adjascent annuli is smaller compared to that between those found later. This is a clear indication of decline in the growth rate with age.

Body length - scale length relationship:

Growth of scale maintains a definite proportion with growth of the body. Regression analysis of this relationship in G. chapra of Baigul and Nanaksagar reservoirs yielded straight line (Fig. 1). The formulated relationships are as under:

$$\text{Log } Y = -0.01125 + 0.00676 \text{ Log } X$$

$$r = 0.9963 \ (P \angle 0.001) \quad \ldots \text{ (Baigul fish)}$$

$$\text{Log } Y = -0.01136 + 0.00684 \text{ Log } X$$

$$r = 0.9654 \ (P \angle 0.001) \quad \ldots \text{ (Nanaksagar fish)}$$

Where Log X = Total length of fish (mm); Log y = Scale length (mm); r = Coefficient of correlation.

Age and Growth rate

Age Composition: Length-frequency distribution data of G.chanra have been embodied in Table I. The percentage composition of 0^+, 1^+, 2^+, 3^+, 4^+, 5^+ was 3.6, 27, 38.7, 14.3, 9.4 and 7 in Baigul fish population, but 1.7, 43.8, 32, 15.2, 4.4, 2.9 in Nanaksagar population, respectively. The 2^+ age group was represented by largest number of individuals in Baigul whereas in Nanaksagar 1^+ was the most abundant of the age groups, and the abundance of successively higher age groups declined significantly. In G. chanra population of each reservoir the variability in each year class was appreciable. However, it was highest in the underyearlings and in the declining order in succeeding age groups.

Growth characteristics: Using scales as indicators of age and growth the mean length at each age (absolute growth) and changes in growth rates of G. chanra are explicited in Tables II, III and Figs. 2, 3 after pooling the data on both sexes. No notable difference seemed to exist in growth characteristics of the fish from two environments. Changes in the annual growth increments were abundantly clear when data related to age groups 0^+ - 5^+ was compared.

Fitting of Von Bertalanffy growth equation to length at age data:

The Von Bertalanffy growth equation: $Lt = l\alpha \left[1-e^{-K(t-t_o)}\right]$ is mainly based on three parameters: $l\alpha$, K and t_o. The graphic transfomation of Ford (1933) and Walford (1946) has been presented in Figs. 4, 5 for Baigul and Nanaksagar fish, respectively. From these figures the asymptotic length ($l\alpha$) were estimated as 215 mm and 208.33 mm for Baigul and Nanaksagar specimens, respectively. The value of 'k' was 0.651 (Baigul) and 0.64 (Nanaksagar) upon which the calculation of 'K' (coefficient of catabolism) is totally based. Values of 'K' and 't_o' (theoretical age) of Baigul and Nanaksagar fish were computed as 'K' = 0.429 (Baigul) and 0.446 (Nanaksagar) and 't_o' = -0.10638 (Baigul) and -0.00695 (Nanaksagar).

Values of '$l\alpha$', 'K' and 't_o' were fed in the growth equation which resulted in the formula:

$$'lt' = 215\left[1-e^{-0.429(t+0.10638)}\right] \quad \text{... (Baigul fish)}$$

$$'lt' = 208.33\left[1-e^{-0.446(t+0.00695)}\right] \quad \text{... (Nanaksagar fish)}$$

From the above growth equation the lengths (lt) at ages I, II, III, IV, V were found out: 81.2 mm, 127.9 mm, 258.3 mm, 178.1 mm and 191.0 mm (Baigul fish) and 75.4 mm, 123.2 mm, 153.8 mm, 173.4 mm and 186.0 mm (Nanaksagar fish). The corresponding observed lengths of these age groups were 83.7 mm, 133.8 mm, 168.2 mm, 183.0 mm and 193.2 mm (Baigul fish) and 79.2 mm, 127.5 mm, 160.8 mm, 182.9 mm and 192.6 mm (Nanaksagar fish). These results show a close agreement between the calculated and observed lengths (Table III, Fig. 6) and justify the applicability of Von Bertalanffy equation in growth studies on *G. chapra*. The empirically calculated weight (using the regression equation) also approximated that observed (Table III, Fig. 7).

DISCUSSION

Causes of growth cessation resulting in the ring/ 'growth check' or annulus formation on the hard parts of fish such as scales, otolith, opercular bone, vertebral centra and spines have been well documented. Causative factors identified are environmental, physiological as well as genetic. Amongst the totality of environmental variables, the temperature and food supply are by far the most influential on growth of the fish. Temperature which alters the rates of metabolic processes may be expected to have a considerable effect on growth of poikilothermous animals (Brown, 1946). Deshmukh (1973) observed ring formation in the scales of *Pomadasys hasta* due to decline in water temperature. In temperate regions where seasons are well defined a drop in temperature during winter is followed by a decrease in metabolic activity as well as intensity of feeding, leading to retardation in growth which is recorded on the scale and other hard parts of the body in the form of growth check. However, during summer season, increase in the temperature is followed by faster growth rate, resulting in a wider ring or band. Usually the fluctuation in temperature is a cyclic phenomenon and temperature drops only once in a year, hence the rings formed as result could be regarded as annual marks. Findings of Dudley (1974) and Serns & Strawn (1975) on tilapia and bluegill very clearly reveal growth retardation and even a complete pause. These strengthen the reliability of rings on scales as annual marks. The water temperature of Baigul and Nanaksagar from where *G. chapra* was obtained varied from -14°C - 33°C and 16°C - 35°C, respectively.

Formation of annuli on skeletal elements is not confined to temperate fish alone but is also reported to occur in inhabitants of tropical and subtropical zones which are characterized by fluctuations in hydrographical conditions and also because of the fact that fishes of these regions show periodicity in spawning effected largely by their biological clock (Qasim, & Bhatt, 1966; Bhatnagar, 1968; Kamal, 1969; Rao, 1962, 1970; Bhatt, 1970). The gonad build-up that involves diversion of proteins, fats, glycogen and other constituents from several parts of the body, chiefly musculature and liver, to the point of their exhaustion (Love, 1970; Mustafa, & Jafri, 1977) and accompanied by marked decline or a complete cessation of feeding activity (Nikolsky, 1963; Mustafa, 1978) emphasize that growth is unlikely and fishes are infact emaciated. It is quite certain that an angular growth check is laid down on the scale during this period of grave physiological emergency in the body. Brown (1946) had also authenticated that in addition to external environmental factors the annual physiological cycle of changes in the internal environment, chiefly because of the alterations in the activity of endocrine glands also contribute to ring formation. The author further stressed that the physiological rhythm in the body of fish in its natural environment is not linked with the so-called environmental 'time markers'. Hickling (1933) also considered the formation of rings on the otolith of adult fish as a manifestation of greatest physiological strain probably caused by maturation and spawning, directly as well as by way of decline in food intake. Seshappa & Bhimachar (1954) observed annuli formation on the scales of a demersal marine fish, malabar sole (Cynoglossus semifasciatus) during South-West monsoon when food at the bottom is depleted. Pantulu (1961, 62), Kamal (1969) and Jhingran (1971) who worked on several teleosts explained that cessation of feeding and spawning exhaustion are cumulatively responsible for appearance of growth check on the scales. Fagade (1980) working on bagrid catfish (Chrysichthysnigrodigitatus) expressed the view that rings are undoubtedly formed by setback in the process of normal growth resulting from any or all of the three factors namely non-availability of food, gonad build-up and inability of the fish to feed despite food availability.

It is clearly evident from the Fig. 8 that in majority of the cases of G. chapra of first year class the annulus is formed in April. It is in this month that feeding intensity of the fish was lowest in comparison with other months and manifests in ring formation. Higher percentage of annuli in subsequent year classes during May-June period which happens to be the peak breeding season imply spawning stress as the only causative factor of annulus formation since feeding activity was not appreciably different from that in other parts of the year. Monthly observations on annuli formation in G. chapra revealed that low feeding intensity in first year class (virgins) and spawning stress in adults of second and subsequent year classes result in the appearance of annuli.

Growth of G. chapra was most rapid during the first year of life but gradually declined with advance in the age, presumably due to transfer of considerable part of the total energy entering the body in the form of food towards gonadal development and availability of relatively smaller amount of the same for assimilation in the tissues for accomplishment of growth. A survey of literature reveals that such a pattern of age-related growth variation has been amply reported for many other fish species (Sarojini, 1957; Qasim & Bhatt, 1966; Bhatt, 1970; Ruelle, 1971; Dudley, 1974; Jafri et al., 1978). Nikolsky (1963) considers this high growth rate in the early phase of life as an adaptation of fish to acquire larger size which can ensure it some protection from predators. Jafri et al. (1978) have elaborated this age-specific growth rate in the light of changes in growth and maintenance rations, alteration in the intake of food per unit of body weight, and some other intrinsic factors. Variation in growth of G. chapra of Baigul and Nanaksagar reservoirs was to small to be interpreted on the basis of racial factors, but could safely be related to differences in water level, food availability and fishing efforts.

Data revealed certain degree of size overlap in various age groups. It was a consequence of prolonged spawning season of G. chapra so that the population of underyearlings of a season were in fact constituted of several stocks generated recruited at different times within the extent of a spawning period.

TABLE - I

Length frequency distribution in different year classes of *G. chapra*

Size groups (mm)	AGE GROUPS						Total
	O^+	I^+	II^+	III^+	IV^+	V^+	
			BAIGUL SPECIMENS				
39 - 70	15	19	-	-	-	-	34
71 - 100	-	72	-	-	-	-	72
101 - 130	-	21	77	-	-	-	98
131 - 160	-	-	83	19	-	-	100
161 - 190	-	-	-	42	39	5	86
191 - 215	-	-	-	-	-	24	24
Total No. of observation	15	112	160	59	39	29	414
Percentage	3.6	27.0	38.7	14.3	9.4	7.0	
			NANAKSAGAR SPECIMENS				
39 - 70	7	33	-	-	-	-	40
71 - 100	-	111	-	-	-	-	111
101 - 130	-	37	62	-	-	-	99
131 - 160	-	-	70	21	-	-	91
161 - 190	-	-	-	42	18	-	60
191 - 215	-	-	-	-	-	12	12
Total No. of observation	7	181	132	63	18	12	413
Percentage	1.7	43.8	32.0	15.2	4.4	2.9	

TABLE - XI

Back calculated lengths of *L. gharra* at the time of annuli formation

Age groups	Length (mm) at different annuli				
	I annulus	II annulus	III annulus	IV annulus	V annulus
			BALGUL SPECIMENS		
1+	83.7±9.2	-	-	-	-
2+	79.8±7.4	147.6±7.0	-	-	-
3+	77.2±9.5	135.8±6.6	169.5±7.1	-	-
4+	63.6±6.8	121.0±5.9	158.6±8.4	184.2±7.5	-
5+	64.1±9.6	110.7±6.9	152.8±5.5	190.2±5.5	196.8±5.5
Mean length (mm)	75.7±8.5	128.8±6.6	160.3±7.0	187.2±6.5	196.8±5.5
			NIZAMSAGAR SPECIMENS		
1+	81.3±9.5	-	-	-	-
2+	78.8±5.7	145.5±7.6	-	-	-
3+	73.7±7.4	132.7±5.2	169.0±5.3	-	-
4+	67.5±6.8	117.6±6.5	155.4±4.4	185.0±7.0	-
5+	62.2±8.1	106.2±7.9	147.2±2.3	176.0±6.0	192.0±5.0
Mean length (mm)	72.7±7.5	125.3±6.8	157.2±4.0	180.5±6.5	192.0±5.0

± Standard error of mean.

TABLE - III

Observed, calculated lengths and weight at each age, and growth characteristics of *G. ghanna*

Age (years)	Observed length (mm)	Calculated length (mm)		$Log_e(L_\infty - lt)$	Yearly growth rate (mm)	Relative growth (%)	Specific growth (%)	Observed weight (g)	Calculated weight (g)
		Scale Method	Von Bertalanffy equation						
					BAIGUL SPECIMENS				
1+	83.7	75.7	81.2	4.94	75.7	38.5	53.2	6.5	3.9
2+	133.8	128.8	127.9	4.46	53.1	27.0	21.9	19.3	17.7
3+	168.2	160.3	158.3	4.00	31.5	16.0	15.5	37.8	32.8
4+	183.0	187.2	178.1	3.33	26.9	13.7	5.0	51.7	50.8
5+	193.2	196.8	191.0	2.90	9.6	4.9	-	62.9	58.5
					NANAKSAGAR SPECIMENS				
1+	79.2	72.7	75.4	4.91	72.7	37.9	54.6	5.0	3.5
2+	127.5	125.5	123.2	4.42	52.8	27.5	22.5	18.7	16.0
3+	160.8	157.2	153.8	3.92	31.7	16.5	13.8	33.0	29.8
4+	182.9	180.5	173.4	3.33	23.3	12.1	6.2	43.9	43.7
5+	192.6	182.0	186.0	2.79	11.5	6.0	-	54.2	51.9

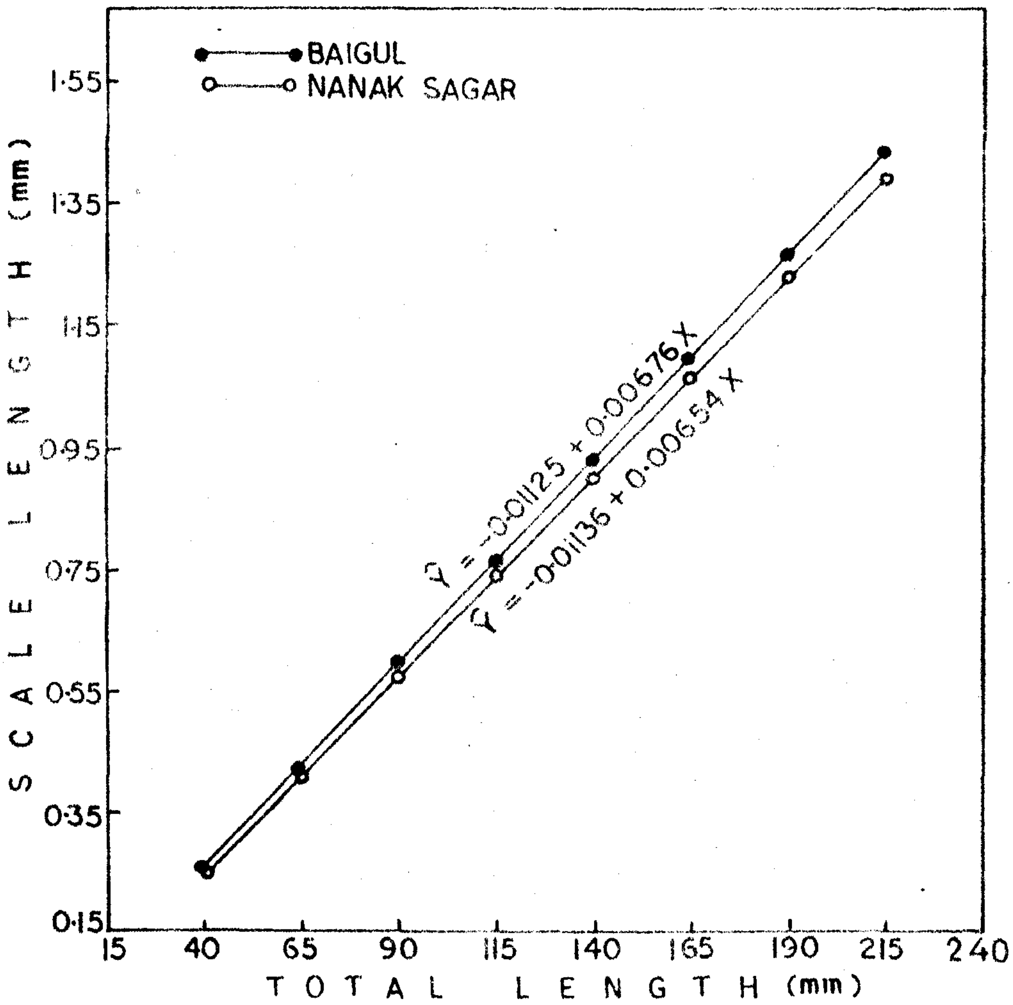
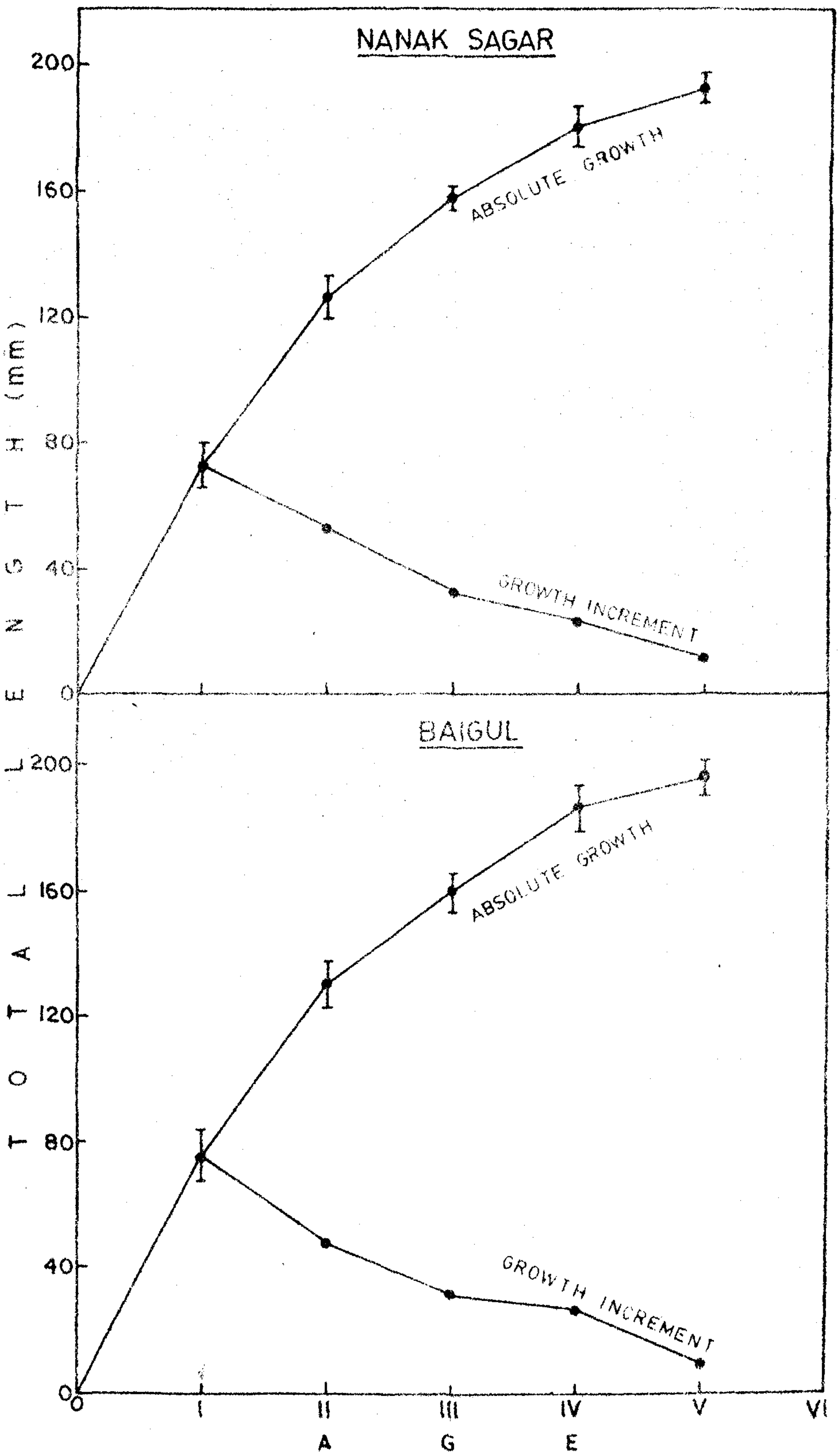

BAIGUL
NANAK SAGAR
SCALE LENGTH (mm)
TOTAL LENGTH (mm)
1·55
1·35
1·15
0·95
0·75
0·55
0·35
0·15
15
40
65
90
115
140
165
190
215
240
Y = -0·01125 + 0·00676 X
Y = -0·01136 + 0·00654 X

Fig. 2. Absolute growth and growth rate of *G. chapra*.



NANAK SAGAR
ABSOLUTE GROWTH
GROWTH INCREMENT
BAIGUL
ABSOLUTE GROWTH
GROWTH INCREMENT
TOTAL LENGTH (mm)
200
160
120
80
40
0
I
II
III
IV
V
VI
AGE

Fig. 3. Specific (instantaneous) growth rate of *C. sharma*.

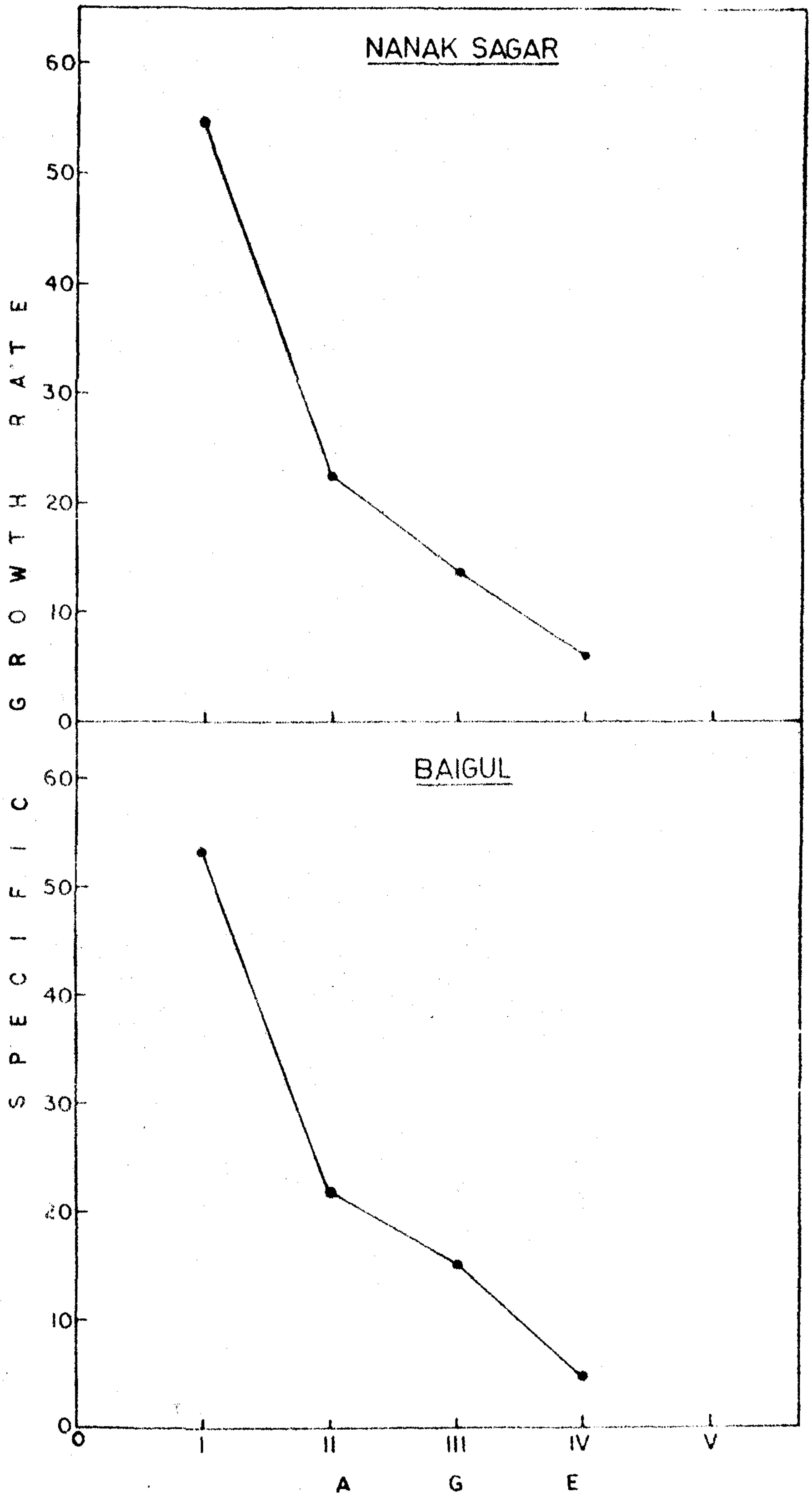
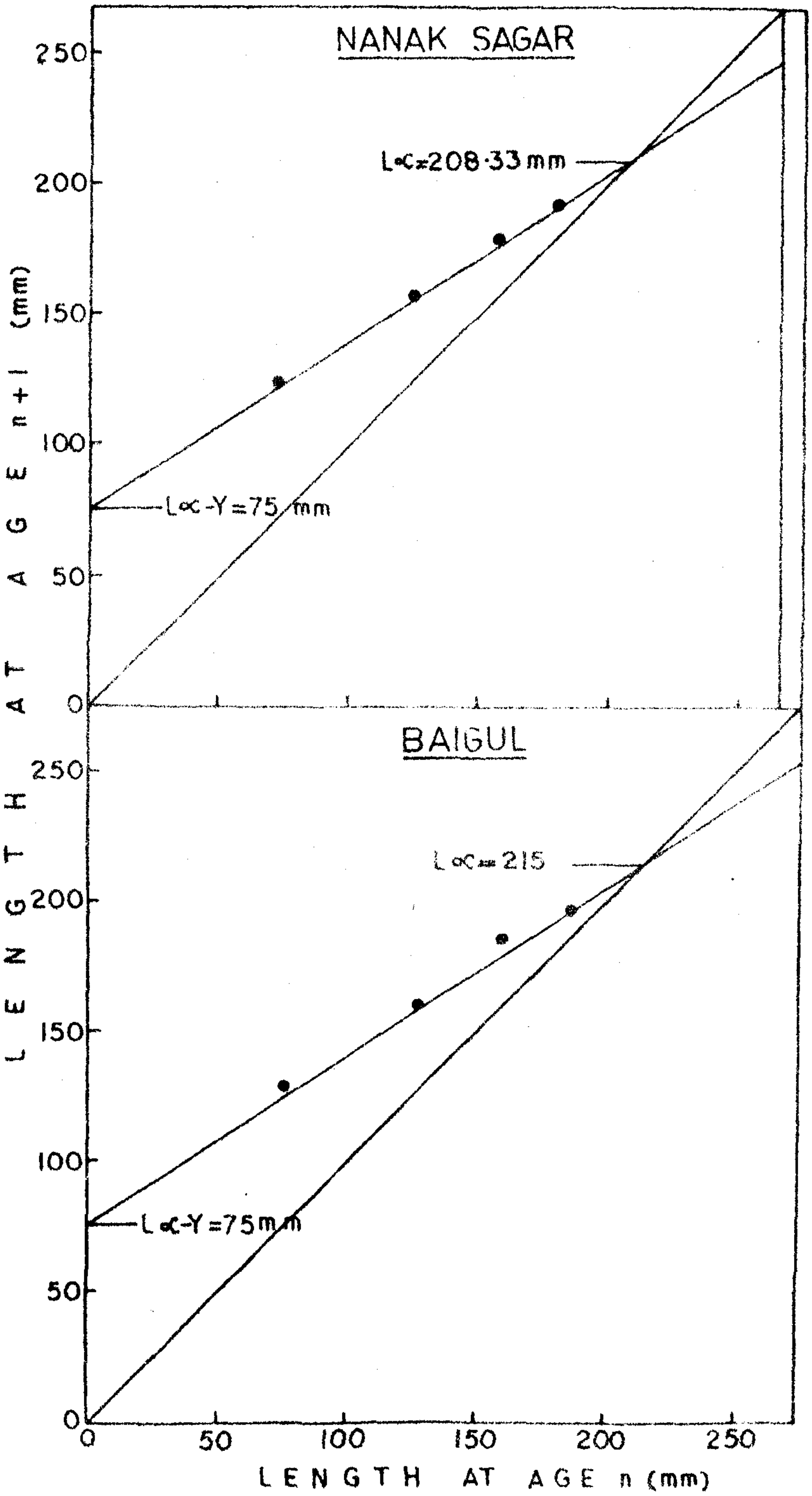
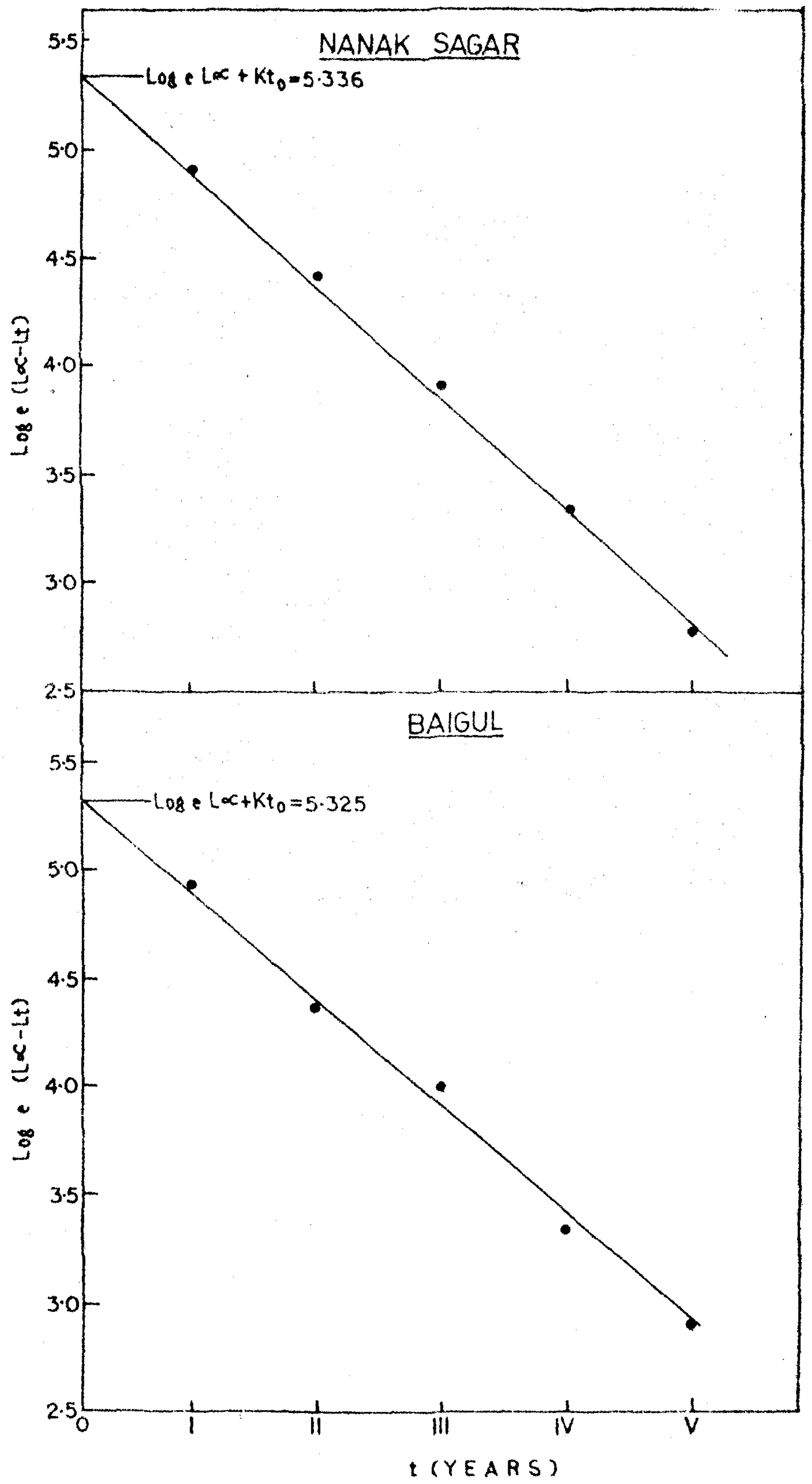

NANAK SAGAR
BAIGUL
S P E C I F I C   G R O W T H   R A T E
0
10
20
30
40
50
60
O
I
II
III
IV
V
A G E

Fig. 4. Ford - Walford plot of the growth of *G. chapra*.



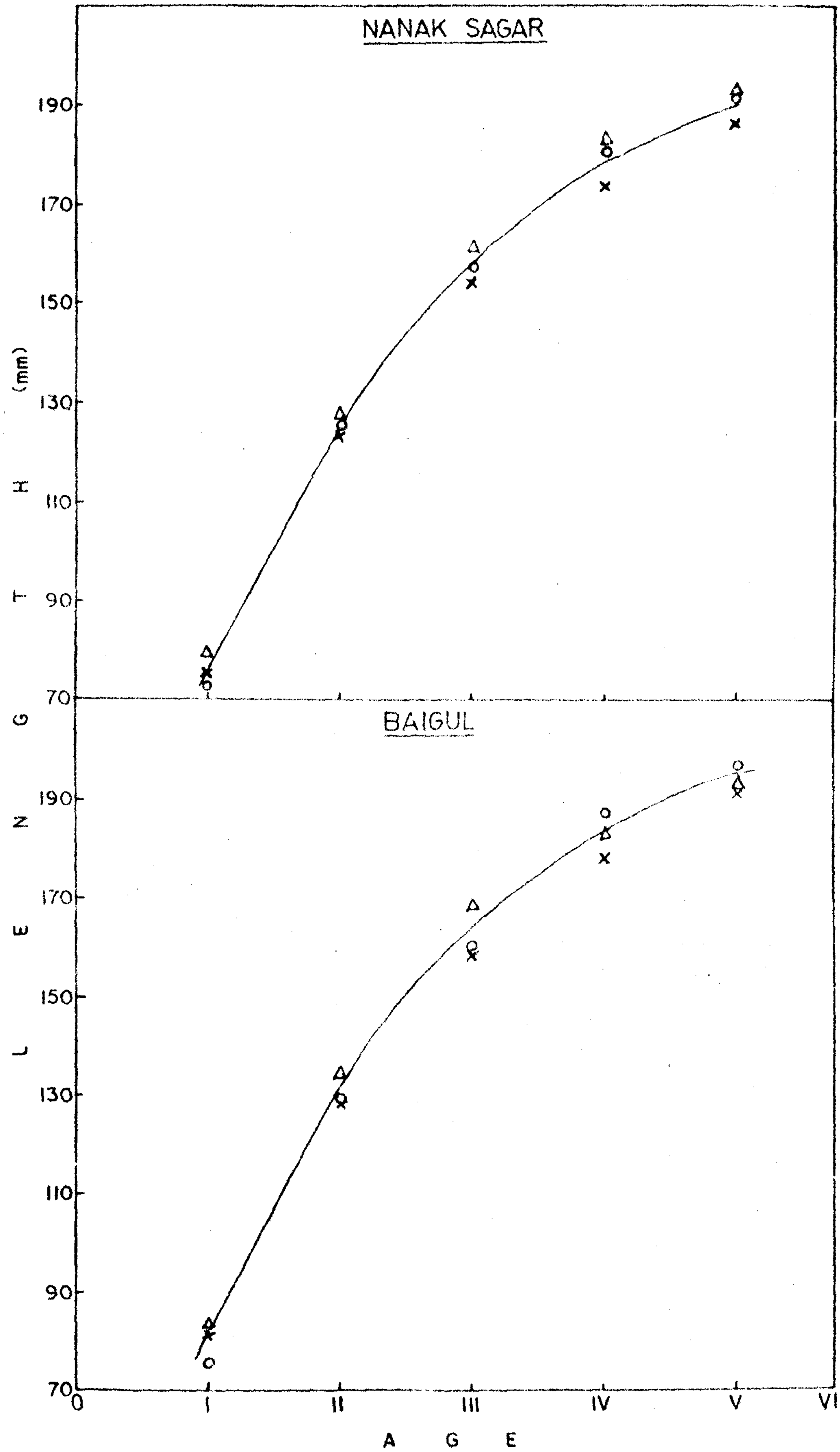
NANAK SAGAR
L∝=208·33 mm
L∝-Y=75 mm
BAIGUL
L∝=215
L∝-Y=75mm
LENGTH AT AGE n+1 (mm)
LENGTH AT AGE n (mm)
0
50
100
150
200
250

Fig. 5. A plot of $\text{Log}_e\ (L\alpha - L_t)$ against age in years (t) for evaluation of 't_o' in G. *chapra*.



NANAK SAGAR
Log e L∝ + Kt0 = 5·336
BAIGUL
Log e L∝+Kt0 = 5·325
Log e (L∝-Lt)
5·5
5·0
4·5
4·0
3·5
3·0
2·5
0
I
II
III
IV
V
t (YEARS)

Fig. 6. Observed and calculated lengths of G. chapra at different ages (observed length, △——△ ; length calculated from length - weight regression equation, ○——○; length calculated from Von Bertalanffy equation, ×——×).



NANAK SAGAR
BAIGUL
LENGTH (mm)
AGE
190
170
150
130
110
90
70
0
I
II
III
IV
V
VI

Fig. 7. Observed (△——△) and calculated (O——O) weight of *G. chapra* at various years of life.

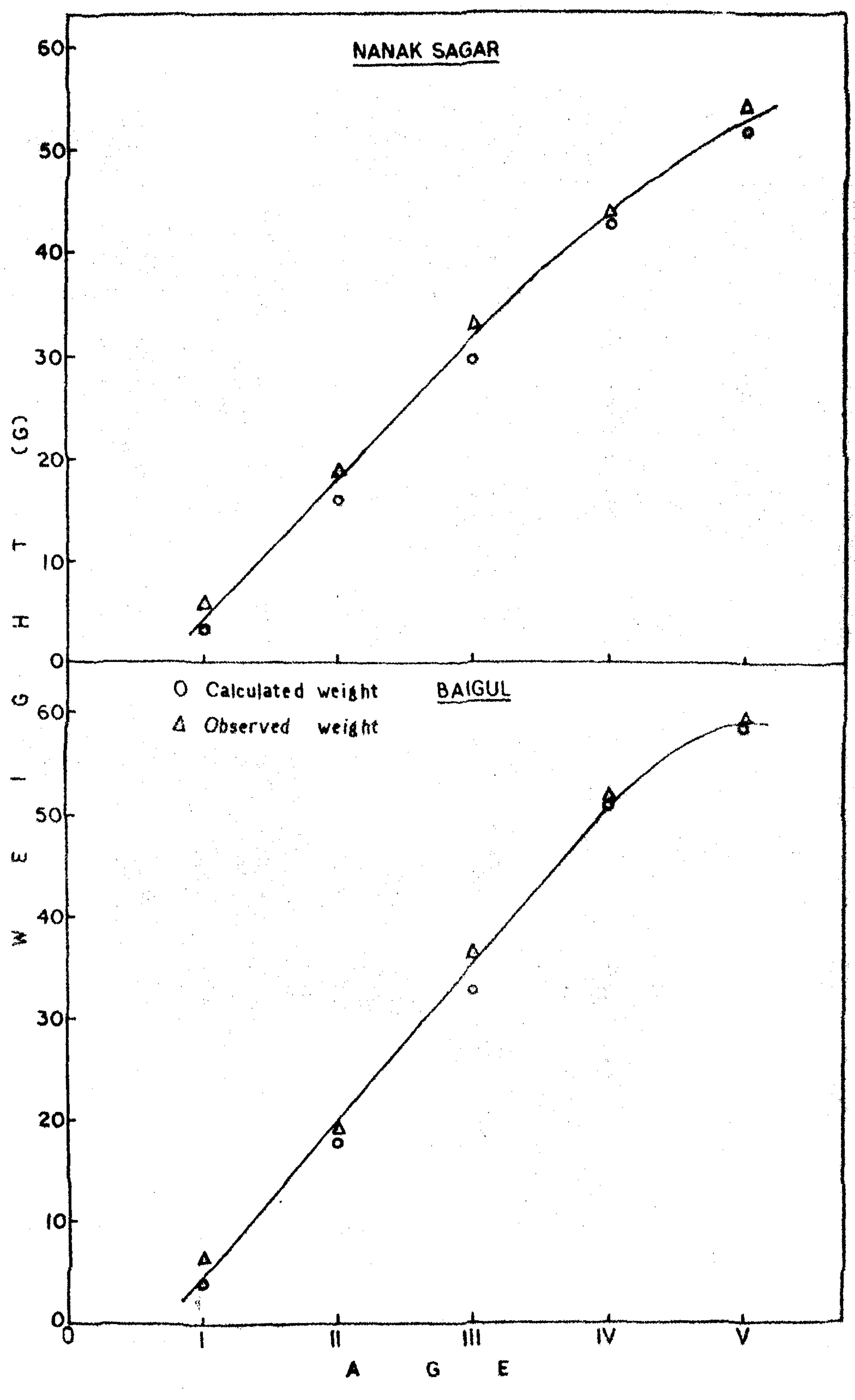
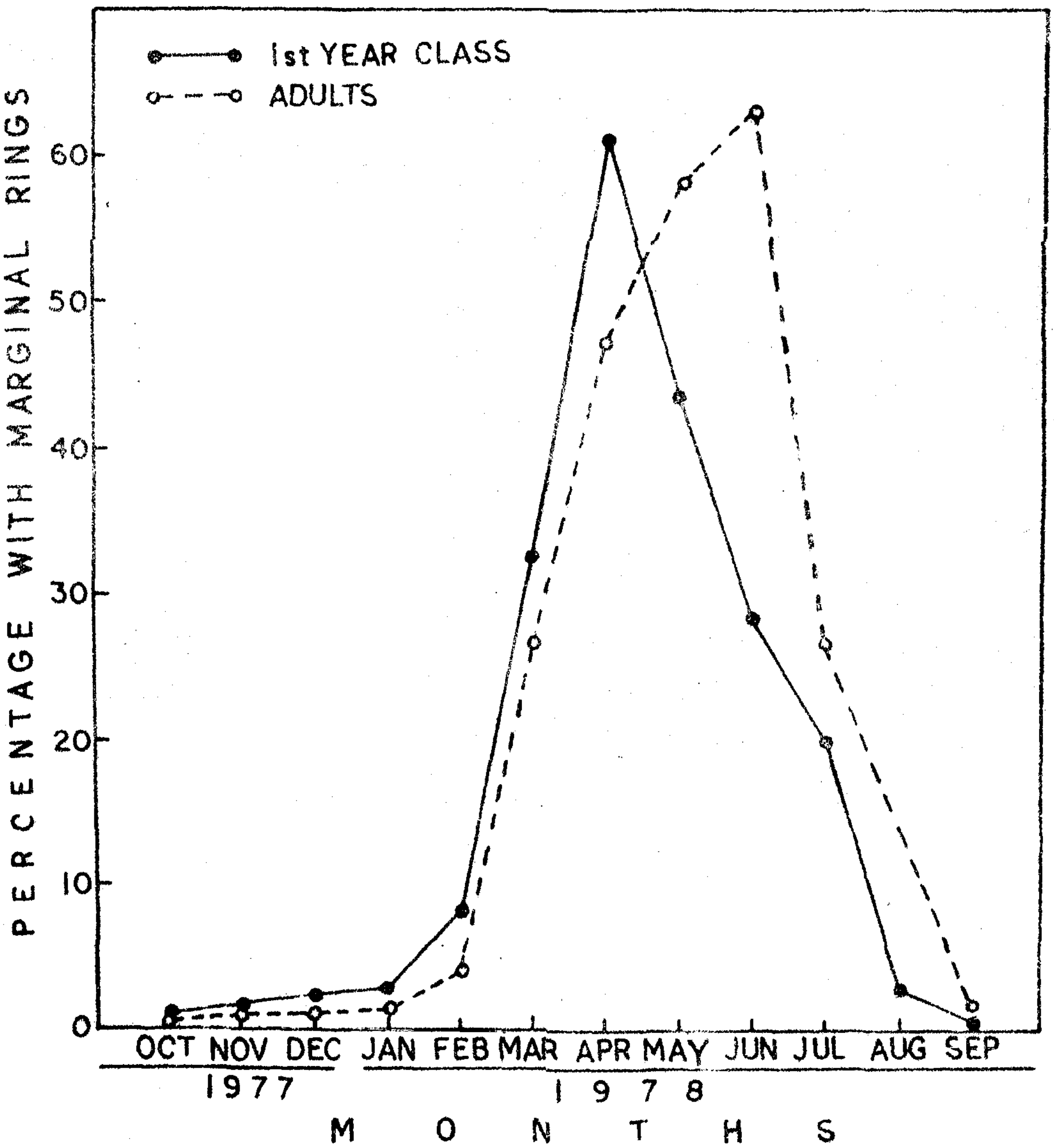

NANAK SAGAR
BAIGUL
O Calculated weight
Δ Observed weight
W E I G H T (G)
A G E
0
10
20
30
40
50
60
I
II
III
IV
V

Fig. 8. Percentage of *C. chanos* specimens with marginal rings in different months.



1st YEAR CLASS
ADULTS
PERCENTAGE WITH MARGINAL RINGS
0
10
20
30
40
50
60
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
1977
1978
MONTHS

C H A P T E R III

LENGTH-WEIGHT RELATIONSHIP

INTRODUCTION

Information on length-weight relationship of fishes is utilized in fishery biology for several purposes such as gaining an idea of the general well being of the fish in an environment, estimation of additional biomass of fish exploited, regulation of fisheries and measurement of the effects of environmental improvement steps (Datta, 1974). These data are helpful in adopting measures for enhancement of the fish yield from a water body. Academically, however, length-weight equation enables calculation of the weight of fish for a given length or vice-versa.

The present investigation is an attempt to establish the length-weight relationship in G. chapra from Baigul and Nanaksagar reservoirs.

MATERIALS AND METHODS

Specimens of G. chapra (total length 39 - 215 mm) numbering 412 (Male, 168 and female, 244) and 414 (male, 151 and female 263) were obtained alive from Baigul and Nanaksagar respectively from October 1977 to September 1978 (Baigul) and January to December, 1978 (Nanaksagar). The sampling from the commercial catches was carried out randomly. Total length - weight relationship was evolved by the help of logarithmic formula:

$$\text{Log } W = \text{Log } a + n \log L$$

where, W = body weight (g), L = total length (mm), log 'a' is empirically, a constant called intercept of the regression, and ('n' is exponent termed as the slope.

Values of log 'a' and 'n' were evaluated by the universally used methods of least squares. Formulae for further statistical processing of the data were the same as outlined by Snedecor & Cochran (1980).

R E S U L T S   A N D   D I S C U S S I O N

Length-weight relationship of males and females of *C. chaura* of different sizes obtained from Baigul and Nanaksagar reservoirs have been given in Figs. 1, 2. The coefficient of correlation and co-variance analysis are presented in Tables I, II. The co-variance value reveals differences (5% level) between specimens of the two reservoirs.

A survey of literature reveals that the value of exponent exhibits interspecific as well as intraspecific variations. The later are usually used to denote the living condition of fish. Hile (1936) and Martin (1949) reported the exponent varying from 2.5 - 4.0 in fishes. Antony Raja (1967) found a range of 2.0 - 5.4 in marine teleosts. Lagren's (1951) consept of cube law suggesting an exponent of 3.0 applies only for an ideal (hypothetical) fish, which fairly serves as a scale to make comparisons with. If the exponent is 3 it indicates poor condition of the fish and $\angle$ 3 emphasizes the robustness. Thus Mustafa (1978) working on Esomus danricus derived an exponent of 3.24 in healthier specimens from flowing water, and 2.63 in individuals of lentic (pond) environment.

Length-weight formula for G. chapra from Baigul and Nanaksagar reservoirs revealed that the exponent was less than 3, suggesting that weight of the fish increased less than cube of the length. Jhingran (1968) who collected this species from Ganga river in Allahabad range also reported the exponent value comparable to the one obtained in the present study. However, Chondar (1973) published results of his work on G. chapra sampled from Keetham lake in Agra showing that weight increased a little more than the length cube. This disparity may be due to sampling artifact or inadequacy of observations by Chondar (1973) or else a manifestation of racial/stock difference, and environmental relations.

A comparison of observed and calculated weights of G. chapra revealed close agreement (Table III). Contrary to this Jhingran (1952) and Khan (1972) working on Indian major carps noticed that the observed weight of smaller specimens (below 100 mm) was less than the calculated weight while in the individuals of larger size (above 100 mm) it was just other way around.

Although marked sex-linked difference in exponent failed to occur in *G. chapra* of either reservoir, but noticeable difference in this parameter was observed between fish of the two environments. Higher growth exponent in Baigul residents compared to inhabitants of Nanaksagar implied that growth in weight to a given length is faster in fish of Baigul reservoir. This can be explained in the light of the ecological factors with special reference to productivity of forage organisms and their availability to fish. Genetic basis of the difference can not, however, be entirely ruled out. Jhingran (1968) and Chondar (1973) have reported two races of this fish from Ganges river and Keetham lake. Growth pattern variation in *G. chapra* from Baigul and Nanaksagar can be attributed to racial differences.

In fish of the size range investigated the males were found somewhat heavier than females of equivalent length, and hence their length-weight curves lie above the one drawn for the female sex. This is suggestive of the fact that the physiological and feeding conditions are more influential on length-weight relation compared to the presumable differential in gonad development. However, Chakraborty & Singh (1963) who worked on *Cirrhina mrigala* documented that in small-sized specimens, males were heavier than the females, whereas the condition was just the reverse in higher size groups.

When empirically derived weights of *G. chapra* of the two reservoirs of the given lengths were compared with corresponding data published by Jhingran (1968) on this species from Ganga river, it was observed that young individuals upto a length of about 35 mm were heavier in the reservoirs selected. Beyond this size and particularly above 75 mm, the riverine dwellers were in more robust condition. It leads one to believe that rheotaxtic response of *G. chapra* varies with its age and growth; the young ones feeling more comfort and quite at home in still water with less of currents, while larger individuals finding running water of the rivers more conducive to their healthy survival. Mustafa (1978) documented that *Esomus danricus* of the flowing water channel were in better condition, with higher ponderal index, than the specimens of this species in ponds and ditches. Based on these data the author reviewed the various environmental relations ranging from the direct mechanical effect of water currents, to these involving nutrient distribution, oxygen circulation, repressive factor dilution, appetite modification, etc., which suggest advantage of living in running water.

TABLE - I

Statistical analysis of the Length-Weight regression equation of *G. chapra*

Parameters	Regression coefficient	S.S. due to regression	Residual S.S	D.f.	Coefficient of correlation 'r'	't'	P	Significant
				BAIGUL SPECIMENS				
Male	2.7867	32.8265	1.4099	167	0.9798 ± 0.0031	63.13	< 0.001	S
Female	2.8402	41.8925	0.9203	243	0.9892 ± 0.0014	104.99	< 0.001	S
Combined	2.8234	79.1556	2.3360	411	0.9855 ± 0.0014	117.61	< 0.001	S
				NANAKSAGAR SPECIMENS				
Male	2.7788	23.9758	0.6347	150	0.9870 ± 0.0021	74.96	< 0.001	S
Female	2.7984	43.3586	0.9787	263	0.9886 ± 0.0014	106.08	< 0.001	S
Combined	2.7704	68.0111	1.6323	413	0.9921 ± 0.0008	160.52	< 0.001	S

S.S. = Mean deviation sum of square, D.f. = Degrees of freedom, S. = Significant.

TABLE - II

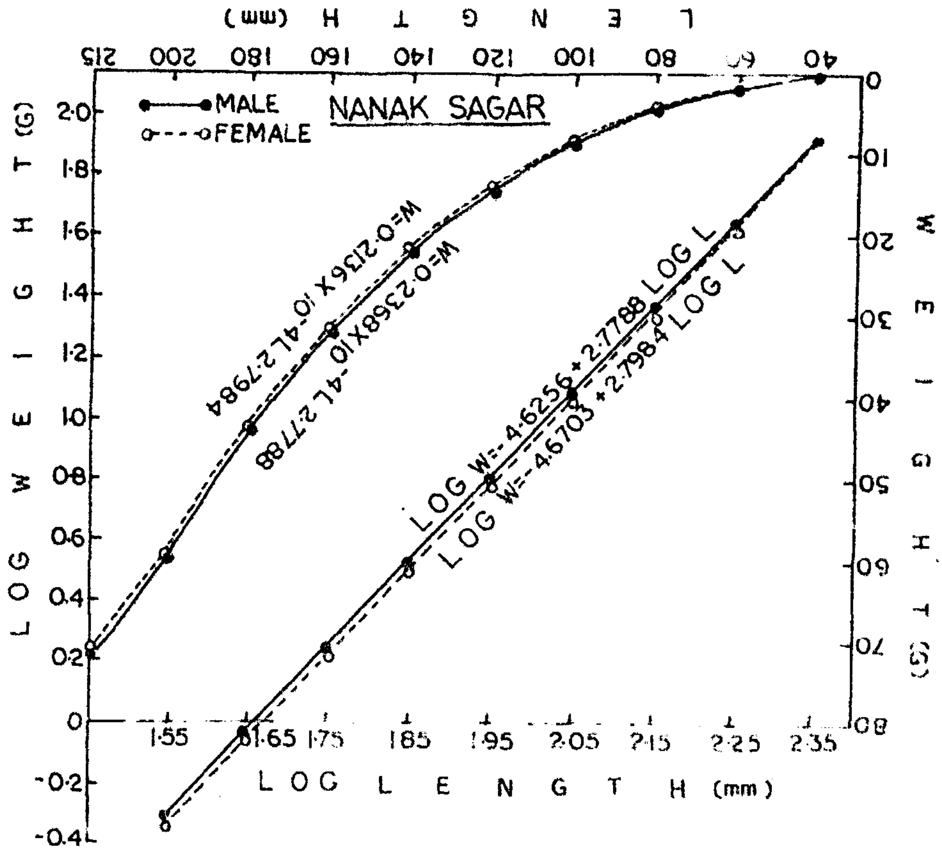
Covariance analysis of Length-weight relation of *G. chapra*.

Characters	Deviation from total regression		Deviation from individual regression			Differences			Observed F	5% F	Significanse
	D.f.	S.S.	D.f.	S.S.	M.S.	D.f.	S.S.	M.S.			
					BAIGUL SPECIMENS						
Male and female	411	2.3460	410	2.3302	0.0057	1	0.0158	0.0158	2.7817	3.86	N.S.
					NANAKSAGAR SPECIMENS						
Male and female	413	1.6248	412	1.6134	0.0039	1	0.0114	0.0114	2.9082	3.86	N.S.
Combined Baigul and Nanaksagar fishes	825	3.9988	824	3.9683	0.0048	1	0.0305	0.0305	6.3542	3.86	S

D.f = Degrees of freedom; S.S. = Sum of deviation square; M.S. = Mean sum of square;

S = Significant; N.S. = Not significant.

Fig. 1. Length - weight relationship in male and female specimens of *G. chapra*.


NANAK SAGAR
MALE
FEMALE
W=0.2136X10⁻⁴L²·⁷⁹⁸⁴
W=0.2368X10⁻⁴L²·⁷⁷⁸⁸
LOG W=-4.6256+2.7788 LOG L
LOG W=-4.6703+2.7984 LOG L
LOG WEIGHT (G)
LOG LENGTH (mm)
LENGTH (mm)
WEIGHT (G)

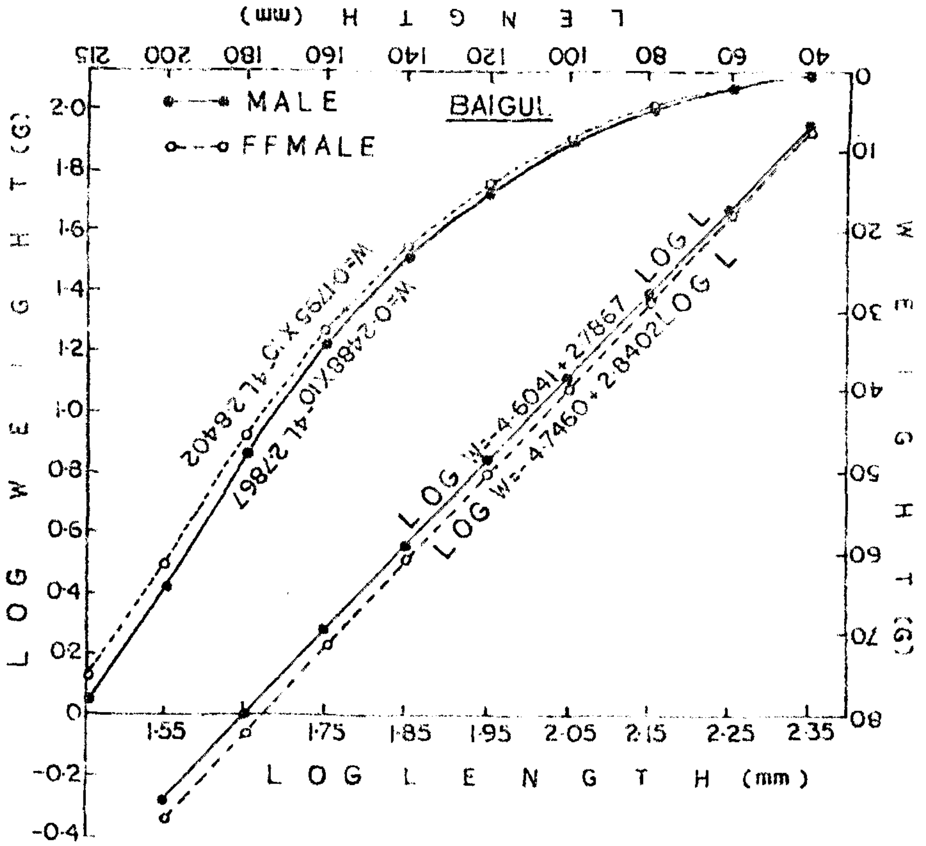
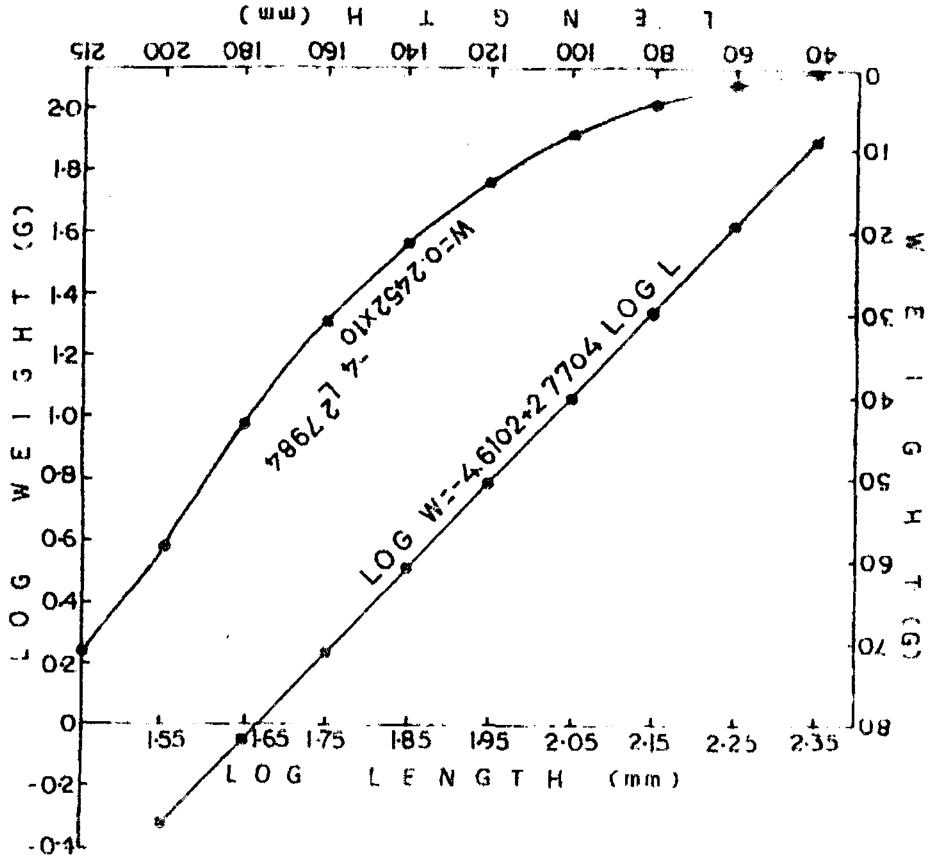
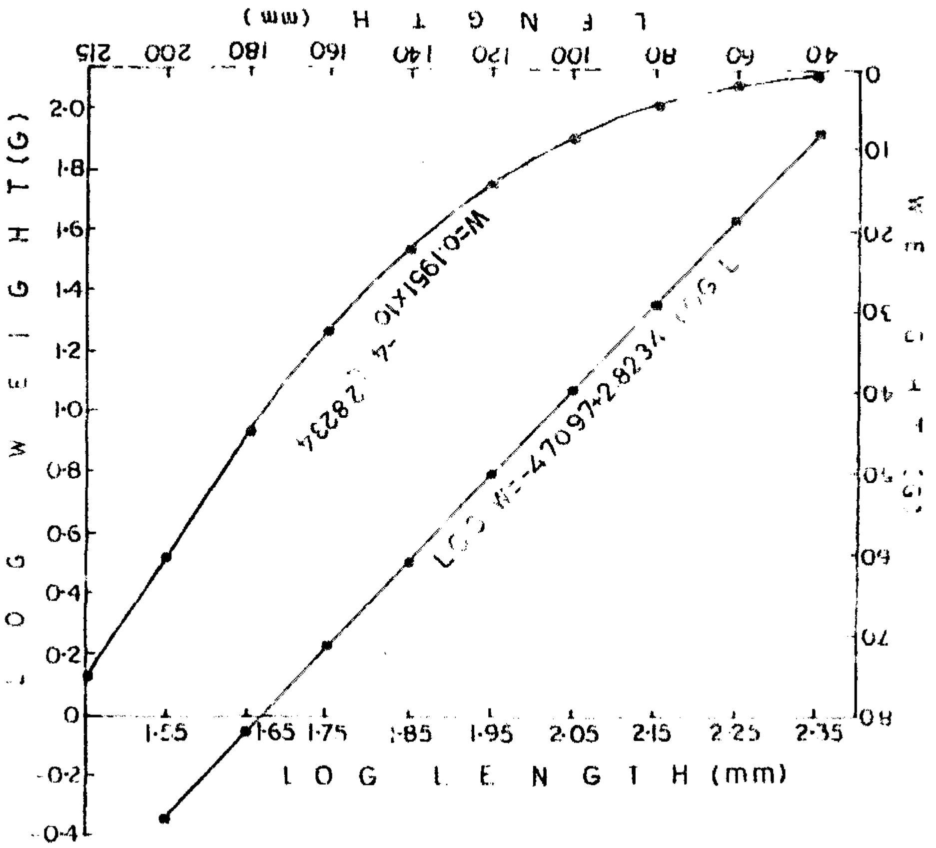

BAIGUL
MALE
FEMALE
W=0.1795X10⁻⁴L²·⁸⁴⁰²
W=0.2486X10⁻⁴L²·⁷⁸⁶⁷
LOG W=-4.6041+2.7867 LOG L
LOG W=-4.7460+2.8402 LOG L
LOG WEIGHT (G)
LOG LENGTH (mm)
LENGTH (mm)
WEIGHT (G)

Fig. 2. Length – weight relationship in *G. ghagra* (sexes combined).


LENGTH (mm)
215 200 180 160 140 120 100 80 60 40
LOG WEIGHT (G)
2·0 1·8 1·6 1·4 1·2 1·0 0·8 0·6 0·4 0·2 0 -0·2 -0·4
WEIGHT (G)
0 10 20 30 40 50 60 70 80
W=0·2452X10 -4 L2·7984
LOG W=-4·6102+2·7704 LOG L
1·55 1·65 1·75 1·85 1·95 2·05 2·15 2·25 2·35
LOG LENGTH (mm)


LENGTH (mm)
215 200 180 160 140 120 100 80 60 40
LOG WEIGHT (G)
2·0 1·8 1·6 1·4 1·2 1·0 0·8 0·6 0·4 0·2 0 -0·2 -0·4
0 10 20 30 40 60 70 80
W=0·1951X10 -4
1·55 1·65 1·75 1·85 1·95 2·05 2·15 2·25 2·35
LOG LENGTH (mm)

CHAPTER IV

R E P R O D U C T I O N

INTRODUCTION

Reproduction is an important function of a fish which accomplishes its propagation and provides for the recruitment so essential for sustenance of a commercial fishery. The quality and quantity of replenished stock depends upon the size and status of spawning population as well as hydrobiological conditions the eggs and larvae are exposed to. A knowledge of the adaptations of fish to reproduction and the ecological factors affecting it reflects many other related features of the life history of the animal. In view of the importance of the study of reproduction biology and paucity of data on this aspect of C. chapra, the present investigation was undertaken. Some of the terms involved in the discussion need elaboration. 'Maturation' refers to cyclic morphological changes which the gonads undergo to attain complete growth and achieve ripeness. The term 'spawning' implies the release of gametes from the body of ripe oviparous fish. The word 'Breeding' is applied to the entire sequence of events characterizing the pre-spawning and spawning stages, whereas 'breeding season' denotes the period of peak maturity and the time during which spawning occurs in fish population. These terminologies have been suggested by Qasim (1973).

MATERIALS AND METHODS

A total of 827 individuals of *G. chapra* (414 from Baigul and 413 from Nanaksagar) were collected during monthly samplings (October, 1977 to December, 1978). After recording the length and weight, the specimens were dissected out, sexed and the stage of maturity was determined according to the standard I.C.E.S. (International Council for the Exploration of the Seas) scale suggested by Qasim (1973) and later adopted by Mustafa (1977 a,b). Gonads were weighed on a balance sensitive upto 0.001 gm and preserved in 10% formalin. For determining gonadosomatic index, gonad weight was expressed as percentage of the intact body weight of the fish (gram). Sub-samples of known weight were removed from the anterior, posterior and middle portions of each lobe of the ovary and number of eggs counted separately. Diameter of the eggs was measured with the help of occular micrometer fitted in a compound microscope, for obtaining information on size-frequency distribution of the oocytes and the breeding season of the fish. Sex ratios of *G. chapra* belonging to different size groups and age, and in different months were evaluated and tested for heterogeneity through the Chi-square (X^2) method. Calculation of percentage composition of immature individuals and those in various phases of maturity yielded data on size and age at first maturity.

OBSERVATION

Monthly variations in the abundance of male and female specimens of *G. chapra* from Baigul and Nanaksagar reservoirs have been indicated in Table I, Fig. 1. The sex ratio varied with season. The range being 1:1 in March to 1:2.8 in September, (Baigul specimens), and 1:1.2 in March to 1:2.4 in June, (Nanaksagar specimens). In almost all the months females maintained numerical superiority over the males (pooled data on age groups) but Chi-square test of heterogeneity showed no significant departure from the hypothetical 1:1 ratio. The relation between the two sexes (male:female) was on the average 1:1.6 in Baigul and 1:1.8 in Nanaksagar specimens, respectively.

Analysis of sex composition of various age groups (Table II, Fig. 2) revealed that with the exception of 0^+ and 1^+ fish of Baigul where males were preponderant, in other age groups (2^+ - 5^+) in this reservoir, and in all age groups of *G. chapra* of Nanaksagar, the number of females was relatively higher.

Gonads, Sexual maturation and Spawning

A pair of gonads lie just ventral to the kidneys on either side of air bladder, within the abdominal cavity. Ripe testes are cylindrical, elongated and creamy white in colour but in immature individuals they are ribbon shaped. Testes remain suspended in the body cavity by delicate and thin mesenteries called mesorchium. Few blood vessels are seen on their surface. From each testis arises a vasa deferentia which runs along its whole length and then the two join posteriorly to form a common duct which communicates with the exterior.

Ovaries when mature are saccular and yellowish. The dense net work of blood capillaries present on their surface imparts a reddish tinge. The immature ovaries are flat, ribbon-like or club-shaped with a yellowish white colour. They remain suspended in the body cavity from the dorsal wall by delicate thin mesovarium. Right lobe of the ovary is slightly larger than the left one in immature stage but the size differential increases with progress in maturation. The two lobes of the ovary are united on the posterior side and lead into an oviduct which opens outside the body.

Gonads of G. chapra were classified into the following 5 maturity stages:

<u>Male</u>

<u>Stage I</u> (Immature virgin)

Testes very narrow, thread-like, transluscent, creamy white vas deferens not distinct, difficult to locate.

<u>Stage II</u> (Maturing virgin or recovering spent)

Testes slightly elongated, opaque, colour somewhat creamy, vas deferens distinct, easy to locate.

<u>Stage III</u> (Ripening)

Testes much distended, club-shaped opaque, cream coloured, vas deferens very distinct.

<u>Stage IV</u> (Ripe)

Testes much swollen, occupying major part of the body cavity; attain maximum weight, cream colour (a little deeper). When pressed even gently a white milt oozes out.

<u>Stage V</u> (Spent)

Testes shrunk; weight drastically reduced; dull colour.

<u>Female</u>

<u>Stage I</u> (Immature virgin)

Ovary small, transluscent, club-shaped, whitish in colour, ova microscopic, transparent, not visible to naked eye, poor vascularity.

<u>Stage II</u> (Maturing virgin or recovering spent)

Ovaries slightly elongated and swollen, light yellow in colour, ova small but visible to naked eye.

Stage III (Ripening)

Ovaries more voluminous, yellowish in colour with reddish tinge due to vascularity. Ova with distinct yolk and visible to unaided eye.

Stage IV (Ripe)

Ovaries considerably large, yellow coloured with reddish appearance in same part, occupying all but a small part of the body cavity. Ova almost rounded and quite conspicuous. Weight maximum.

Stage V (Spent)

Ovaries shrunk without ova or with few residual ones. Weight highly reduced. Yellowish and poorly vascular.

The monthly relative abundance of males and females of the various stages of maturity has been incorporated in Table III and Fig. 3. A definite seasonal cycle of maturation was evident. The immature virgins (stage I) and maturity virgins or recovering spent fish (stage II) of both sexes were available throughout the year except during June, July and August, in both the reservoirs. In the period September-February gonads were rather inactive. From March the ripening individuals (stage III) began to appear in the population and during April they were predominant. In June both the sexes were completely ripe and this stage was seen to occur upto August but became scarce in September. Spent specimens appeared first in July, indicating the commencement of spawning in this month. The maximum number of spents was registered in July (male = 70%, female = 68.7% - Baigul; male = 72.7%, female = 73.7% - Nanaksagar) and August (male = 83.3%, female = 81.3% - Baigul; male=83.3%, female = 78.8% - Nanaksagar). It was also recorded that the large-sized fish mature earlier than the smaller ones.

The cycle of maturation and development of gonads was accompanied by remarkable changes in their weight. Inactive phase of the gonads was characterized by low gonadosomatic index which increased as gonads entered the active phase and passed into more advance stage, and touched an all time low when spent. Data pertaining to monthly gonadosomatic index of both sexes in either reservoir have been embodied in Table IV and Fig. 4. It is evident that the seasonal changes in gonado-somatic index of males were less marked than those of the females. In both the sexes the gonadosomatic index increased markedly from March and peaked in June. With the onset of spawning it declined abruptly. It is further discernible that gonadosomatic index of large-sized fish was higher in May while that of younger individuals in June.

The percentage of mature fish of different sizes has been shown in Fig. 6. Males in Baigul reservoir were found mature for the first time on attaining a length of 115 mm while females at 121 mm. In Nanaksagar however, males and females mature at 120 and 125 mm, respectively.

Observations on unspawned eggs in the ovary gave a reliable picture of the spawning frequency. In the breeding season the oocytes were found to undergo a series of changes in size, shape and inclusions. The cycle of maturation of ova is completed a little before spawning at which time they are fully ripe. The ovary contained only one batch of maturing ova at a time. Year round studies in size frequency distribution of intraovarian eggs (Fig. 5) gave information on the act of spawning in the fish. The various stages of maturity of ovary outlined earlier were characterized by following developmental phases in the contained ova:

Stage I

Oocytes were transparent, small (0.1 mm), numerous yolkless, irregular in shape, with a relatively larger eccentric nucleus.

Stage II

Oocytes contained small vacuoles along the peripheral cytoplasm, yolk material appeared in small quantity, diameter of eggs averaged 0.26 mm.

Stage III

Oocytes transluscent, more amount of yolk, somewhat yellowish in colour, about 0.45 mm in size.

Stage IV

Ova transluscent, spherical, or elliptical, characterized by abundance of yolk and oil globule of yellowish colour, average size 0.67 mm.

Stage V

Gonads were spent.

No remarkable differences were observed in diameter of ova sampled from anterior, middle and posterior regions of ripe ovary. The ova from the two lobes were also of almost identical diameter. Size of mature individuals had no effect on egg diameter i.e., sizes of eggs of different reproductive age groups were identical.

Progression in the size of developing ova in different months and their frequency distribution can be understood from the data in Table V, and Fig. 5.

During the study period monsoon commenced towards the end of June. Rains were heavy in July, resulting in flooding of the reservoir. Current velocity was high, downstream. Ripe fish migrated upstream from the deeper parts and selected shallow areas as their spawning ground where the velocity of water current, temperature, pH and alkalinity were moderate. It was preferentially during the showers and cloudy weather that congregation of the two sexes and spawning occurred. After spawning individuals moved to deeper water of the reservoir.

D I S C U S S I O N

Sex ratio in fishes is known to vary from one population to another of the same species and may even change with various years of life (Nikolsky, 1963). Deviations from its hypothetical 1:1 value besides indicating actual difference in the sex composition of the natural population can also be related to a number of factors. Concordant to present observations on G. chapra, Rita & Nair (1979) found in other species of teleosts a general preponderance of females over males. Interestingly, this was even more marked during the breeding season. Perhaps females burdened with considerably developed gonads in comparison with the testes in males become more passive and vulnerable to fishing, hence their greater number in the catch. Possibility of the segregation of sexes during the breeding season and thereby heterogeneity in their distribution at any particular locality in the reservoir as a factor causing increased susceptibility of a sex to fishing can not be ruled out. Bennet (1962), McFadden & Cooper(1962), Bailey (1963) and

Bodola (1955) expressed the view that in older fish dominance of females is sometimes so remarkable as to leave little doubt that males complete their life span earlier than the females, making a noticeable rise in the percentage of the fair sex. It can not also be overlooked that larger size of the females compared to the males of the same age offers protection against predation.

Evidently, males must be more easily foraged and thus outnumbered by the opposite sex in a population.

Gonad in the fish seemed to assume vigorous activity from the month of March which ultimately culminated in ripeness in May-June. The availability of spent individuals together with eggs and larvae from July (with the advent of monsoon) onward upto August and rarely even in September, demonstrated the extents of the spawning period of G. chapra. Nikolsky's (1963) concept of the act of spawning as a reaction to some natural stimulus or signal of a complex character seems true in this case. Changes in climatology and weather conditions such as development of clouds, thunder storm, precipitation manifesting in rains which bring about a sequence of hydrological changes such as reduction in temperature, pH, increase in water level, currents, oxygen circulation, dilution of the repressive factor, could obviously induce spawning in the fish.

Protandry was clearly evident in G. chagra, the males with milting gonads were common in later half of May whereas ripe females, almost in 'running' condition, were abundantly seen in June. The male potential spawners continued to be represented in the population till the females of their stock complete the spawning. Clearly, it is an adaptive feature ensuring fertilization of maximum possible eggs.

Early maturation of large-sized individuals which have spawned one or more times earlier in their life compared to those preparing for first breeding, seems invariably an outcome of early commencement of the process of their gonad build-up. Pantulu (1963) and Chakraborty & Singh (1963) observed in major carps the development of gonads in virgins striving for maturity starting later in the season.

Presence in the ovary of the ova in the same stage of development in any season signified that spawning takes place only once in a year and is confined to a definite restricted season. Depletion of gametes from July resulted in pre-ponderanse of spent fish. As the ripe specimens give way to spents, the later become more frequent and former reciprocally reduce in number, becoming rare by the end of August. Their presence in September is only exceptional. Frequency polygon vis-a-vis ova diameter make the succession of various maturity stages amply clear. Ova diameter of any particular maturity stage remained fairly constant in Baigul and Nanaksagar counterparts. The only difference noticeable in the maturation activity between stocks of G. chapra of the two reservoirs was the time of first maturity. An early attainment of maturity in dwellers of Baigul could be linked to food supply. Nikolsky (1963) discussed that rich food supply enhances growth and accelerates maturity, leaving thereby no scepticism that maturity is related to size. The high is the food intake, more assimilation of food and its conversion into flesh, the faster is the growth which manifests in virgin individuals acquiring maturity earlier than those growing slowly, mostly as a result of inadequate supply of food and other abiotic factors in their natural environment.

TABLE - I

Monthly variation in the number and percentage of males and females, and test of heterogeneity for sex ratio of *G. chapra*.

Months	No. of Males	No. of Females	% of Males	% of Females	Combined	Ratio M : F	X^2	Significance
BAIGUL SPECIMENS								
October	13	18	41.9	58.1	31	1:1.38	0.81	N.S.
November	12	22	35.3	64.7	34	1:1.82	2.95	N.S.
December	13	22	37.1	62.9	35	1:1.69	2.31	N.S.
January	16	19	45.7	54.3	35	1:1.19	0.26	N.S.
February	17	23	42.5	57.5	40	1:1.35	0.90	N.S.
Marbh	23	23	50.0	50.0	46	1:1.00	0.00	N.S.
April	18	25	41.9	58.1	43	1:1.39	1.14	N.S.
May	16	25	39.0	61.0	41	1:1.56	1.98	N.S.
June	11	15	42.3	57.7	26	1:1.36	0.62	N.S.
July	10	16	38.5	61.5	26	1:1.60	1.38	N.S.
August	12	16	42.9	57.1	28	1:1.33	0.57	N.S.
September	7	20	25.9	74.1	27	1:2.86	6.29	S
Total	168	244	-	-	412	-	-	
Mean	14.0	20.33	42.3	59.8	34.33	1:1.55	-	
NANAKSAGAR SPECIMENS								
January	12	23	34.3	65.7	35	1:1.92	3.46	N.S.
February	16	22	42.1	57.9	38	1:1.38	0.26	N.S.
March	19	23	45.2	54.8	42	1:1.21	0.26	N.S.
April	14	21	40.0	60.0	35	1:1.50	1.40	N.S.
May	15	27	35.7	64.3	42	1:1.80	0.71	N.S.
June	10	24	29.4	70.6	34	1:2.40	6.43	S
July	11	19	36.7	63.3	30	1:1.73	4.83	S
August	12	18	40.0	60.0	30	1:1.50	3.46	N.S.
September	10	21	32.3	67.7	31	1:2.10	6.43	S
October	11	20	35.5	64.5	31	1:1.82	4.83	S
November	10	21	32.3	67.7	31	1:2.10	6.43	S
December	11	24	31.4	68.6	35	1:2.18	4.83	S
Total	151	263	-	-	414	-	-	
Mean	12.58	31.92	36.24	63.76	34.50	1:1.80	-	

t = 3.84 at 5% level for 1 D.f.

TABLE - II

Relative abundance of males and females of *G. chapra* of different year classes

Age groups	No.of Males	No.of Females	% of Males	% of females	Combined	Ratio M : F	x^2	Significance
				BAIGUL SPECIMENS				
0^+	21	17	55.3	44.7	38	1:0.81	0.42	=N.S.
1^+	56	37	60.2	39.8	93	1:0.66	3.88	S
2^+	62	101	38.0	62.0	163	1:1.63	9.33	S
3^+	11	50	18.0	82.0	61	1:4.55	24.93	S
4^+	13	27	32.5	67.5	40	1:2.08	4.90	S
5^+	5	12	29.4	70.6	17	1:2.40	2.88	N.S.
Total	168	244	-	-	412	-	-	
Mean	28.0	40.8	38.9	61.1	68.7	1:2.02	-	
				NANAKSAGAR SPECIMENS				
0^+	15	24	38.5	61.5	39	1:1.60	2.08	N.S.
1^+	52	73	41.6	58.4	125	1:1.40	3.43	N.S.
2^+	58	96	37.7.	62.3	154	1:1.66	9.38	S
3^+	15	44	25.4	74.6	59	1:2.93	14.25	S
4^+	7	21	25.0	75.0	28	1:3.00	7.00	S
5^+	4	5	44.4	55.6	9	1:1.25	0.11	N.S.
Total	151	263	-	-	414	-	-	
Mean	25.17	43.83	35.4	64.6	69.0	1:1.97	-	

S = Significant; N.S. = Not significant

t = 3.84 at 5% level for 1 D.f.

TABLE - XXI

Frequency of occurrence of different maturity stages of *C. ghanam* in different months.

Months	Year	MATURITY STAGES																			
		MALE										FEMALE									
		I		II		III		IV		V		I		II		III		IV		V	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ullal Specimens																					
October	1977	10	76.9	3	23.1	-	-	-	-	-	-	5	27.8	13	72.2	-	-	-	-	-	-
November	"	6	50.0	6	50.0	-	-	-	-	-	-	9	40.9	13	59.1	-	-	-	-	-	-
December	"	8	61.5	5	38.5	-	-	-	-	-	-	8	57.1	14	42.9	-	-	-	-	-	-
January	1978	6	37.5	10	62.5	-	-	-	-	-	-	6	31.6	13	68.4	-	-	-	-	-	-
February	"	13	76.5	4	23.5	-	-	-	-	-	-	5	21.7	18	78.3	-	-	-	-	-	-
March	"	11	47.8	10	43.5	2	8.7	-	-	-	-	6	26.0	12	52.2	4	17.4	1	4.4	-	-
April	"	5	27.8	6	33.3	6	33.3	1	5.6	-	-	9	36.0	4	16.0	6	24.0	6	24.0	-	-
May	"	1	6.3	4	25.0	9	56.3	2	12.5	-	-	1	4.0	6	24.0	10	40.0	8	32.0	-	-
June	"	-	-	-	-	3	27.3	8	72.7	-	-	-	-	-	-	5	33.3	10	66.7	-	-
July	"	-	-	-	-	-	-	3	30.0	7	70.0	-	-	-	-	-	-	5	31.3	11	68.7
August	"	-	-	-	-	-	-	2	16.6	10	83.3	-	-	-	-	-	-	3	18.7	13	81.3
September	"	2	28.6	4	57.1	-	-	-	-	1	14.3	3	15.0	13	65.0	-	-	1	5.0	3	15.0
Kankanady Specimens																					
January	1978	5	41.7	7	58.3	-	-	-	-	-	-	11	47.8	12	52.2	-	-	-	-	-	-
February	"	9	56.3	7	43.7	-	-	-	-	-	-	7	31.8	15	68.2	-	-	-	-	-	-
March	"	12	63.2	6	31.6	1	5.3	-	-	-	-	7	30.5	10	43.5	5	21.7	1	4.4	-	-
April	"	5	35.7	7	50.0	2	14.3	-	-	-	-	5	23.8	8	38.1	6	28.6	2	9.5	-	-
May	"	2	13.3	4	26.7	7	46.7	2	13.3	-	-	5	18.5	6	22.3	9	33.3	7	25.9	-	-
June	"	-	-	-	-	3	30.0	7	70.0	-	-	-	-	-	-	10	41.7	14	58.3	-	-
July	"	-	-	-	-	1	9.1	2	18.2	8	72.7	-	-	-	-	2	10.5	3	15.8	14	73.7
August	"	-	-	-	-	-	-	2	16.7	10	83.3	-	-	1	5.6	-	-	3	16.7	14	77.8
September	"	1	10.0	6	60.0	-	-	-	-	2	20.0	1	4.8	10	47.6	-	-	1	4.8	9	42.8
October	"	7	63.6	4	36.4	-	-	-	-	-	-	10	50.0	10	50.0	-	-	-	-	-	-
November	"	5	50.0	5	50.0	-	-	-	-	-	-	8	38.1	13	61.9	-	-	-	-	-	-
December	"	5	45.5	6	54.5	-	-	-	-	-	-	10	41.7	14	58.3	-	-	-	-	-	-

TABLE - IV

Seasonal variations in the gonadosomatic index of male and female of *G. chapra*

Months		Baigul fish G.S.I. Male	Baigul fish G.S.I. Female	Months		Nanaksagar fish G.S.I. Male	Nanaksagar fish G.S.I. Female
October	1977	0.45 ± 0.09	0.98 ± 0.09	January	1978	0.40 ± 0.09	1.07 ± 0.15
November	"	0.48 ± 0.08	1.04 ± 0.09	February	"	0.56 ± 0.12	1.34 ± 0.16
December	"	0.50 ± 0.11	1.15 ± 0.10	March	"	0.68 ± 0.15	1.94 ± 0.11
January	1978	0.54 ± 0.12	1.18 ± 0.08	April	"	1.20 ± 0.10	2.68 ± 0.13
February	"	0.66 ± 0.11	1.42 ± 0.21	May	"	1.64 ± 0.16	3.43 ± 0.23
March	"	0.88 ± 0.14	2.16 ± 0.28	June	"	2.12 ± 0.17	3.98 ± 0.26
April	"	1.33 ± 0.08	2.95 ± 0.37	July	"	1.12 ± 0.12	2.02 ± 0.14
May	"	1.78 ± 0.16	4.10 ± 0.34	August	"	0.56 ± 0.08	1.04 ± 0.15
June	"	2.32 ± 0.26	4.72 ± 0.25	September	"	0.50 ± 0.09	0.98 ± 0.16
July	"	1.36 ± 0.21	2.24 ± 0.31	October	"	0.48 ± 0.08	0.94 ± 0.14
August	"	0.64 ± 0.14	1.18 ± 0.16	November	"	0.46 ± 0.11	0.90 ± 0.15
September	"	0.50 ± 0.16	1.08 ± 0.18	December	"	0.44 ± 0.10	0.96 ± 0.10

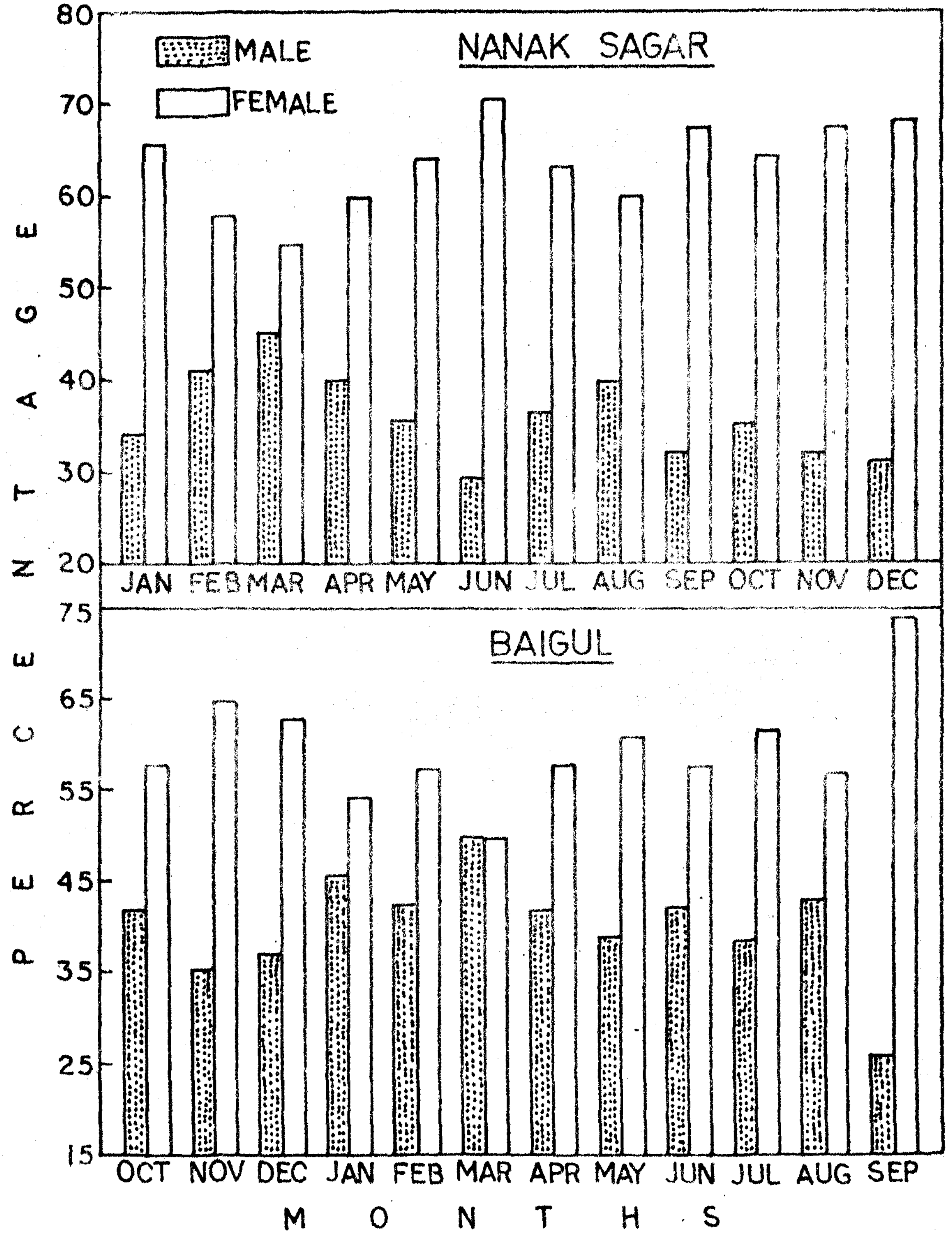
± = Standard error of mean.

TABLE - V

Size frequency distribution and percentage of intraovarian oocytes of *G. chapra*

Micro-divisions (mm)	1978 March No.of ova	1978 March Percentage	1978 April No.of ova	1978 April Percentage	1978 May No.of ova	1978 May Percentage	1978 June No.of ova	1978 June Percentage
BAIGUL SPECIMENS								
14 - 16 (0.25-0.28)	7	7.3	-	-	-	-	-	-
17 - 20 (0.30-0.35)	27	28.1	15	9.7	-	-	-	-
21 - 23 (0.37-0.40)	33	34.4	40	26.0	11	7.8	-	-
24 - 27 (0.42-0.47)	26	27.1	50	32.5	35	24.8	12	11.1
28 - 30 (0.49-0.52)	3	3.1	39	25.3	46	32.6	30	27.5
31 - 34 (0.54-0.60)	-	-	10	6.5	35	24.8	37	33.9
35 - 37 (0.62-0.65)	-	-	-	-	14	10.0	25	22.9
38 - 41 (0.66-0.72)	-	-	-	-	-	-	5	4.6
NANAKSAGAR SPECIMENS								
14 - 16 (0.25-0.28)	7	8.3	-	-	-	-	-	-
17 - 20 (0.30-0.35)	20	23.8	12	10.5	-	-	-	-
21 - 23 (0.37-0.40)	28	33.4	30	26.3	15	10.7	-	-
24 - 27 (0.42-0.47)	21	25.0	37	32.5	36	25.7	12	13.0
28 - 30 (0.49-0.52)	8	9.5	27	23.7	45	32.1	26	28.3
31 - 34 (0.54-0.60)	-	-	8	7.0	34	24.4	34	37.0
35 - 37 (0.62-0.65)	-	-	-	-	10	7.1	20	21.7
38 - 41 (0.66-0.72)	-	-	-	-	-	-	-	-

Fig. 1. Monthly abundance (%) of male and female specimens of G. chapra.



MALE
FEMALE
NANAK SAGAR
BAIGUL
80
70
60
50
40
30
20
75
65
55
45
35
25
15
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
PERCENTAGE
MONTHS

Fig. 2. Relative abundance of the two sexes of _G. chapra_ of different age groups.

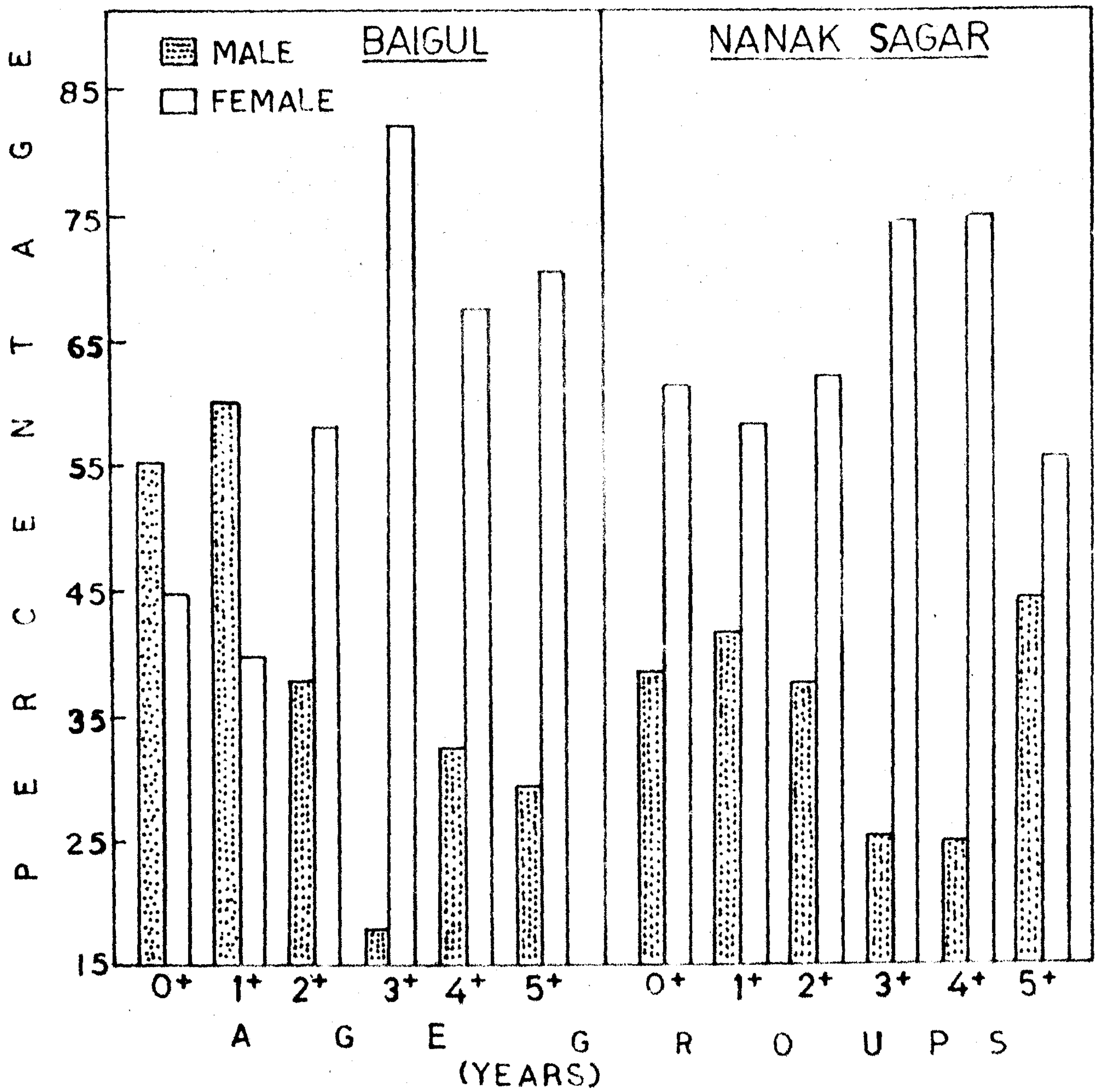
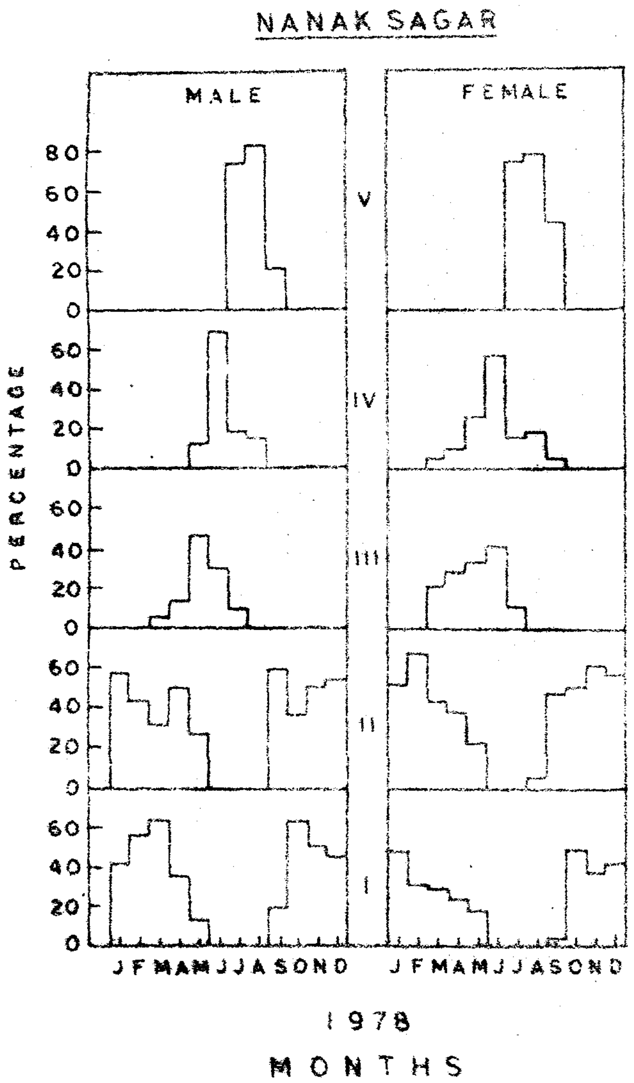
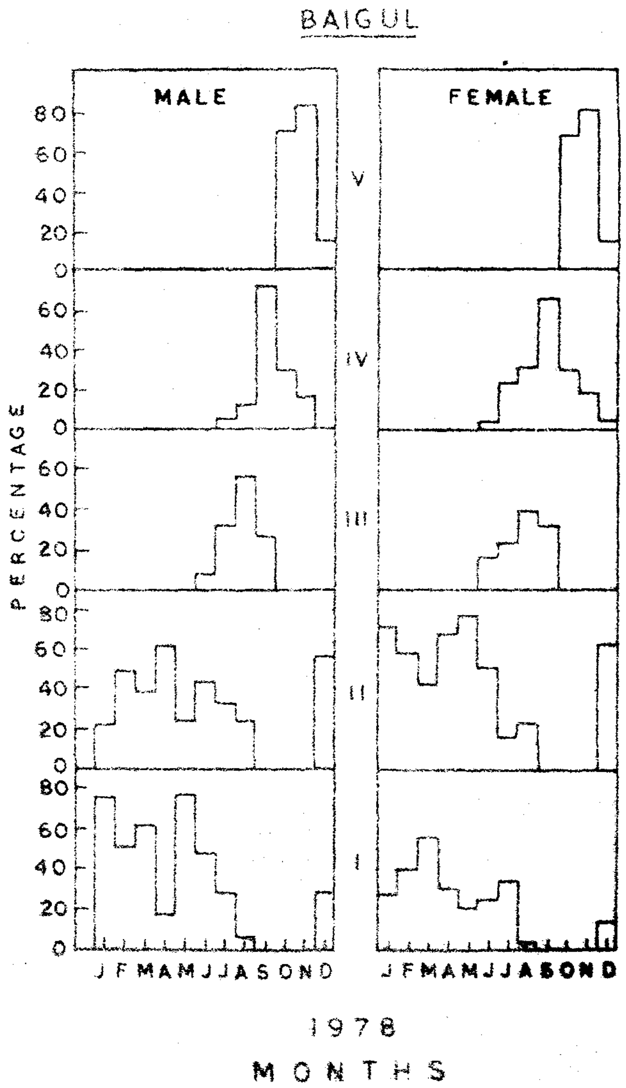

MALE
FEMALE
BAIGUL
NANAK SAGAR
PERCENTAGE
85
75
65
55
45
35
25
15
0+ 1+ 2+ 3+ 4+ 5+
0+ 1+ 2+ 3+ 4+ 5+
AGE GROUPS
(YEARS)

Fig. 3. Monthly relative abundance of maturity stages of *G. chapra*.



NANAK SAGAR
MALE
FEMALE
V
IV
III
II
I
PERCENTAGE
J F M A M J J A S O N D
1978
MONTHS



BAIGUL
MALE
FEMALE
V
IV
III
II
I
PERCENTAGE
J F M A M J J A S O N D
1978
MONTHS

Fig. 4. Seasonal variations in gonadosomatic index of *G. chapra*.

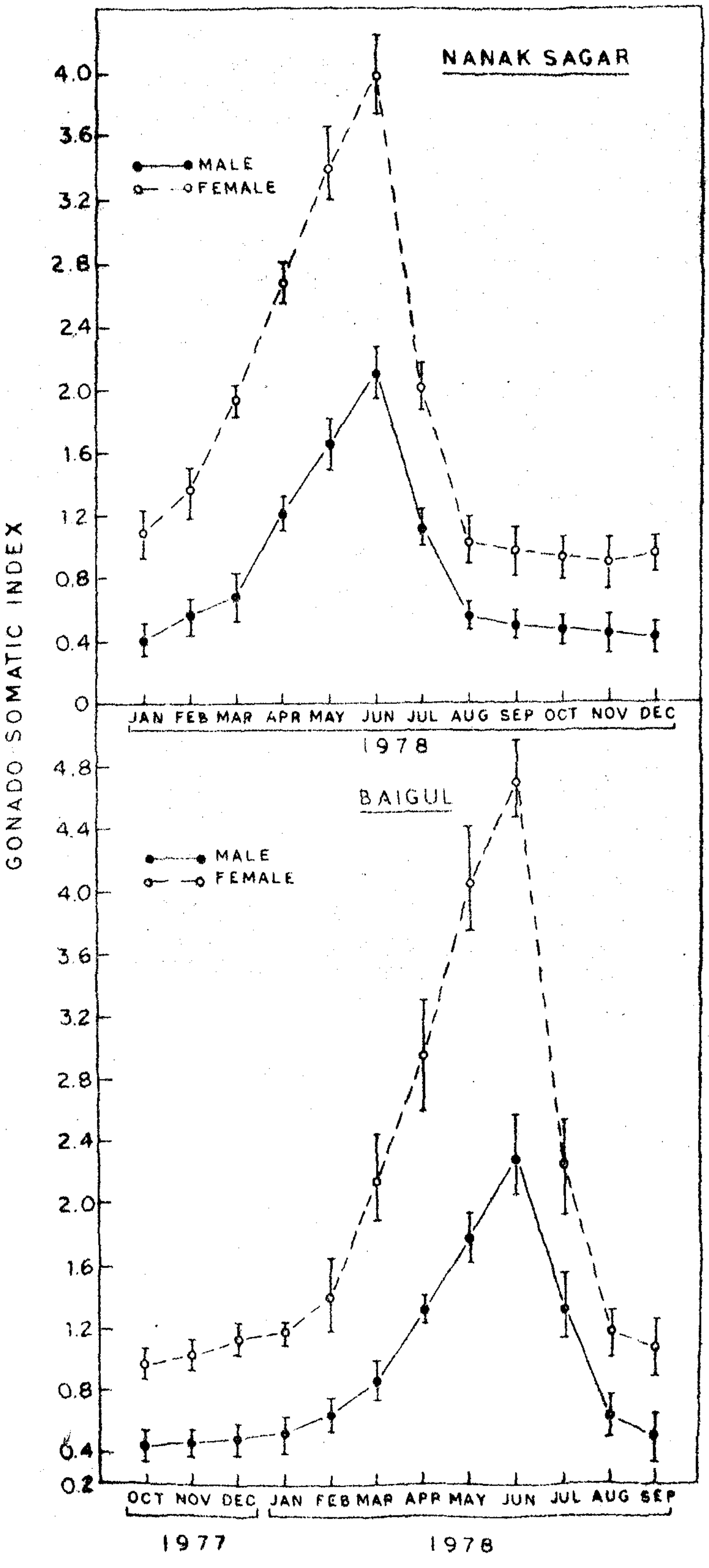
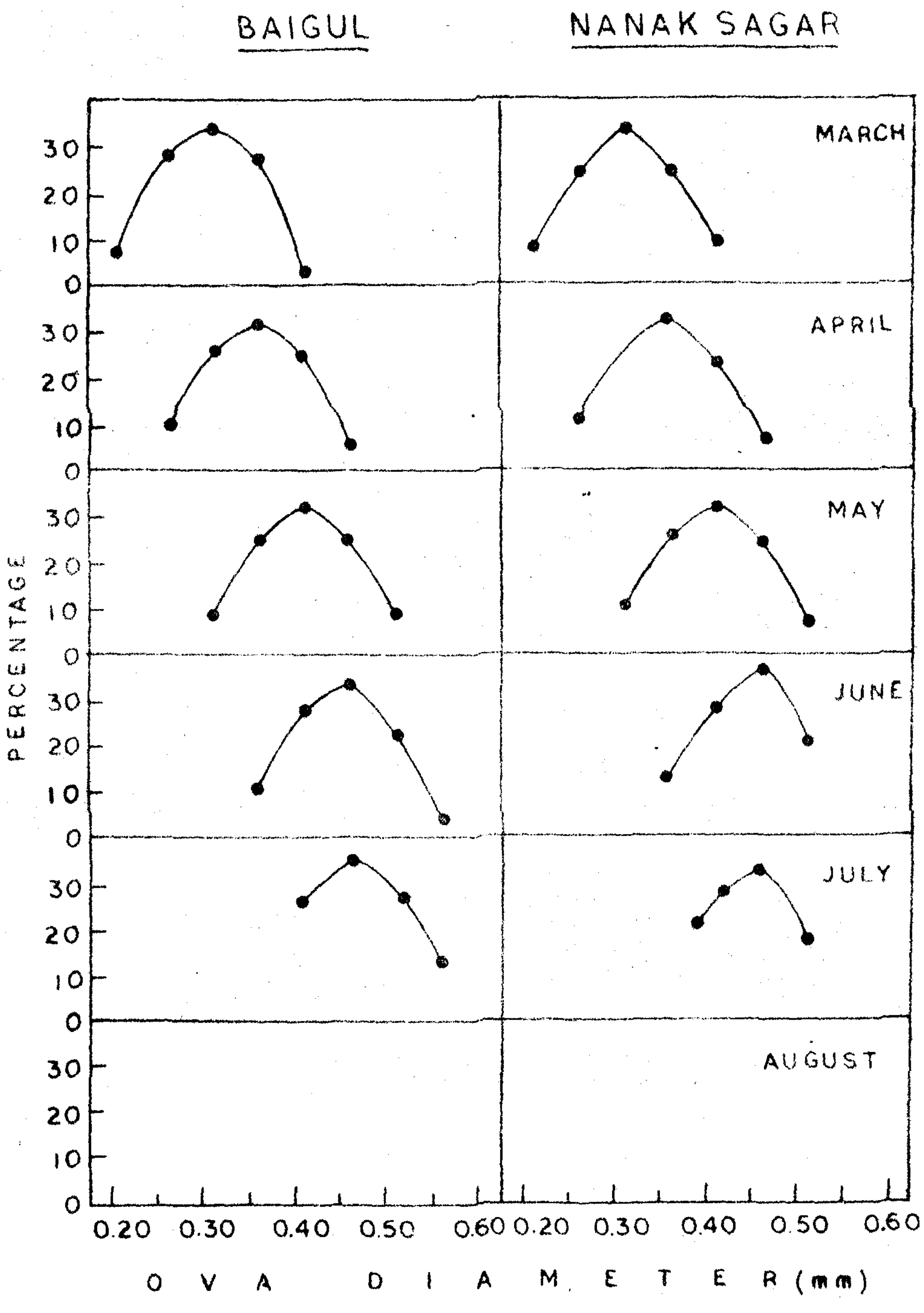
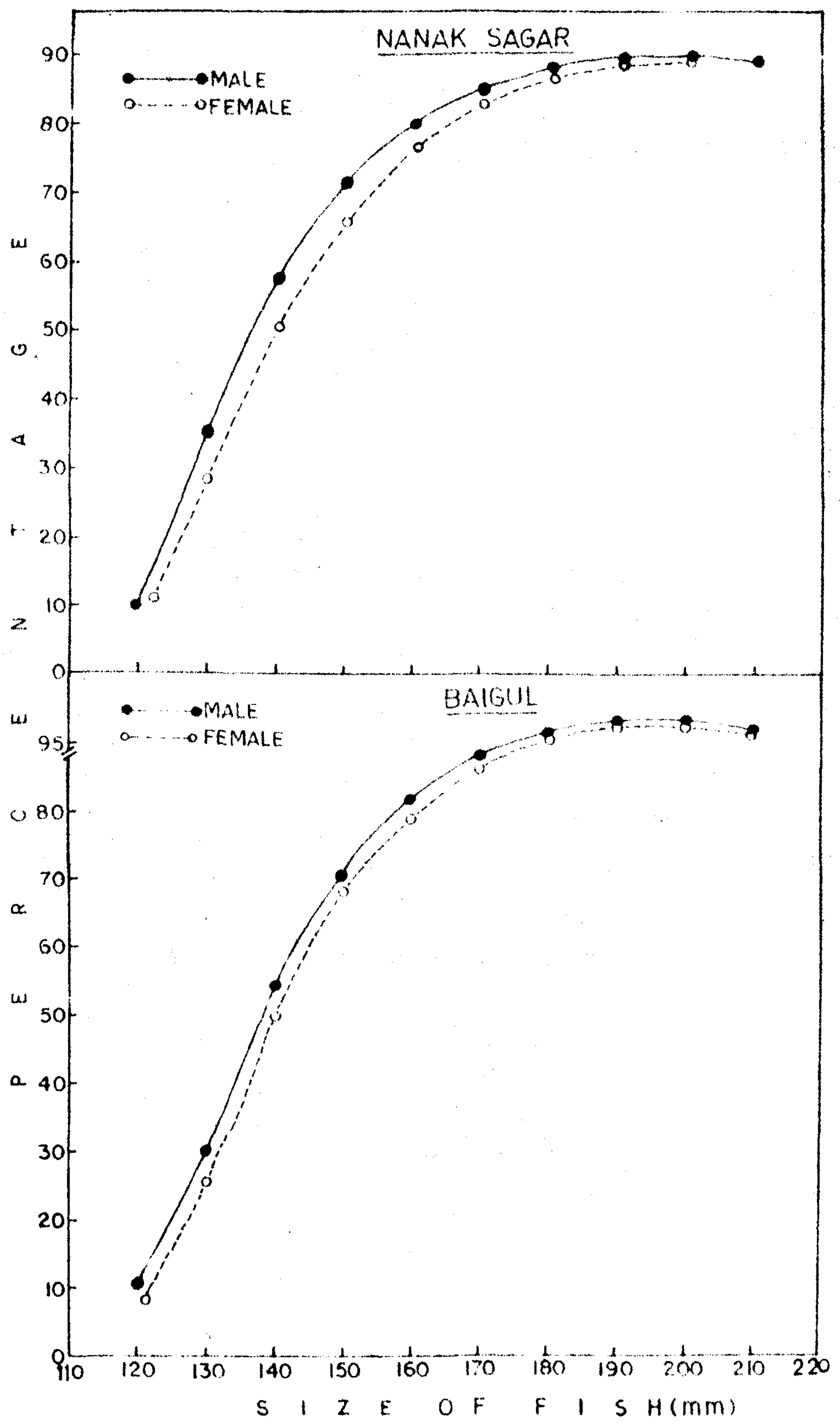

NANAK SAGAR
MALE
FEMALE
GONADO SOMATIC INDEX
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1978
BAIGUL
MALE
FEMALE
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.2
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
1977
1978
MONTHS

Fig. 5. Size frequency of intraovarian oocytes in the breeding season of *S. chaura*.



BAIGUL
NANAK SAGAR
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
PERCENTAGE
0
10
20
30
0.20
0.30
0.40
0.50
0.60
OVA DIAMETER (mm)

Fig. 6. Percentage of mature specimens of _G_. _chacma_ at different sizes.


NANAK SAGAR
MALE
FEMALE
BAIGUL
MALE
FEMALE
P E R C E N T A G E
S I Z E O F F I S H (mm)
0
10
20
30
40
50
60
70
80
90
95
110
120
130
140
150
160
170
180
190
200
210
220

CHAPTER V

F E C U N D I T Y

I N T R O D U C T I O N

Knowledge of fecundity of a fish species is important for determining 1) spawning potential and its success (Qasim, 1973), 2) density dependent factors influencing population size (Simpson, 1951), 3) fluctuations in the egg production potential of individuals of a stock related to life processes such as age and growth (Nagasaki, 1958; Hodder, 1964; Ludwig & Lange, 1975), and 4) environmental factors (Nikolsky, 1963; Wydoski & Cooper, 1966; Bagenal, 1969; De Vlaming, 1971; Tyler & Dunn, 1976) and also 5) separation of various races in a population (Fairan, 1951). In pisciculture data pertaining to reproductive potential is used to formulate the degree of rearing facilities needed and to assess success of the operation.

Considerable work has been done on fecundity of Indian freshwater teleosts. Some of the notable contributions being those of Sinha (1976), Bhatt *et al.* (1977), Rita & Nair (1978), Reddy (1979), Joshi & Khanna (1980) and Varghese (1980). However, excepting for a brief information on fecundity of *G. ghamra* from Keetham lake in Agra (Uttar Pradesh) published by Chondar (1977), no other report is available on this commercial species of teleost. The present study deals extensively with the fecundity of *G. ghamra* from two huge reservoirs, Baigul and Nanaksagar, in the Nainital district of Norther India.

MATERIALS AND METHODS

Live specimens of G. chapra were collected on random basis from the commercial catches of Baigul and Nanaksagar reservoirs during 1977-78. Measurements of total length, body weight and length and weight of the ripe ovaries were made. In all 33 individuals from Baigul reservoir and 27 specimens from Nanaksagar reservoir were analysed. Sub-samples of known weight (10 mg) were taken out from three different regions of each ovary, placed in petridish, and the ova were separated for counting. Mean of the triplicate enumerations was calculated and from this the total number of ripe ova in the paired ovary (absolute fecundity) was computed. For determining relative fecundity the number of ova in unit body length (per mm), body weight (per g) and in unit ovary length and ovary weight were determined. Relationships of the individual fecundity with the total body length, body weight, ovary length, ovary weight and age of the fish were worked out through standard regression equations. Statistical significance of the various correlations have been evaluated according to the methods suggested by Snedecor & Cochran (1980).

RESULTS AND DISCUSSION

Data on fecundity of G. chapra related to body length weight, length and weight of ovary and age have been summarized in tables I A,B, II and Figs. 1-5. The individual fecundity of the fish exhibited intraspecific fluctuations. It varied from 11393 to 82419 eggs (mean = 42739) in fish of Baigul and from 11544 to 56824 eggs (mean = 30187) in specimens of Nanaksagar. The fecundity seemed to maintain relationship with the length, weight and age of G. chapra as also the length, and weight of the ripe ovaries. It increased more than 3 (3.7978, Baigul fish and 3.7859, Nanaksagar fish) times the increase in body length. A very wide range of the exponential values have been reported by various workers. Saigal (1964) and Devraj (1973) found as low as 1.04 and 1.6 values for Mystus aor and Ophicephalus marulius, respectively. Rao (1970) and Saxena (1972) published data on Gerres oyena and Rita rita indicating that fecundity increased about square of the length. Bhatnagar (1964, 1972) and Bowering (1978) observed exponential values ranging 3-4 in Labeo fimbriatus, Labeo dero and Glyptocephalus cynoglossus, whereas Varghese (1980) recorded almost five times increase in case of Coilia dussumieri.

When the relation of fecundity with body weight was worked out, exponents of 1.3 and 1.2 were obtained in samples of G. chapra from Baigul and Nanaksagar, respectively. Higher value of coefficient of correlation in this relationship made it clear that fecundity is more closely related to body weight compared to body length. Chaturvedi (1976), Sinha (1976), Bhatt *et al.* (1977) have also reported linear relationships between the two parameters in Indian teleosts. Nonlinear parabolic relationships were, however, recorded by Rao (1970), Selvaraj *et al.* (1972), Varghese (1980). Values obtained by these workers, nerverthelees, approximate the ones derived in the present study for G. chapra. Mathur (1964), Saigal (1964) and Devraj (1973) working on Hilsailisha, Mystus osteobagrus and Ophiocephalus marulius, respectively documented that fecundity increased 2/3 power of body weight.

Lengthening of the ovary of G. chapra was accompanied by 2.79 and 2.86 times increase in the fecundity of the fish from Baigul and Nanaksagar, respectively. The value of fecundity coefficient of Lepidocephalus thermalis evaluated by Rita & Nair (1979) is quite close to that in G. chapra. Obviously a more voluminous ovary accomodates larger number of ova. Quite unlike with the length the fecundity of this species did not spectacularly rise with weight of the ovary; the fecundity - ovary weight coefficient being only 1.11 Baigul and 1.22 (Nanaksagar). This suggested no marked increase in egg production with growth in ovary weight. Obviously it is not only because of the eggs that an ovary can put on some weight but the permanent ovarian tissues are also contributory. These tissues may in fact increase in proportion as the ovary becomes more heavier though fecundity remaining constant.

In G. chapra fecundity increased but less than square of the age. The exponential values were 1.85 and 1.30 in individuals of Baigul and Nanaksagar, respectively, though the correlation was not as much strong as in the fecundity - body length and fecundity - body weight. Concordant findings are available in the works of several investigators in the past (Hodder, 1963; Pitt, 1964, May, 1967; Wolfert, 1969; Lear, 1970; Bowering, 1978).

The discrepancy in individual growth rate within each age group seems to be the causative factor of the poor fecundity - age correlation, since weight has the overriding influence than age.

An interesting point worth noticing is the fecundity difference in G. chapra of the Baigul and Nanaksagar reservoirs. Higher fecundity of the Baigul specimens can be linked with a number of factors among which food supply and intraspecific competition being the most important. Swardson (1949) reported increase in the reproductive potential under conditions of low intraspecific competition for food and space. Scott (1962) and Martin (1970) observed a direct relation between food supply and egg production. According to Atwood (1960), Bajenal (1969), DeVlaming (1971), Stauffer (1976), Tyler & Dunn (1976) and Healey (1978) better nourished fish produce eggs earlier in life and in larger number than the malnourished individuals.

If these views are given credence one can presume differences in the conditions prevailing in the two reservoirs with special reference to resources of food, space, population density of the fish and intraspecific competition. Whether *C. chanra* of the two reservoirs belong to different stocks with different egg production potential can not be ascertained, although McGregor (1923) separated the races of chinook salmon on the basis of egg counts. Racial segregation based upon fecundity differences has also been advocated by Aro & Broadhead (1950) in sockeye salmon population belonging to different habitats. Wolfert (1969) believed that Walleye of eastern and western basins of the lake Erie which differed in their reproductive potential were different stocks, rarely intermixing at any stage of life.

TABLE I

Length, weight of ripe ovaries, and the fecundity of S. [illegible]

A.

Age (years)	Length of fish (mm)	Weight of fish (g)	Length of ovary (mm)	Weight of ovary (g)	Gonadosomatic index	Fecundity 'F'
			BATGUL SPECIMENS			
II	121	16.0	34	0.790	4.5	11776
II	121	15.5	35	0.770	5.0	11595
II	122	16.5	35	0.810	4.9	12477
II	130	18.5	35	1.070	5.8	13764
II	137	23.0	43	1.550	6.7	17308
II	142	25.0	44	1.490	5.9	19575
II	143	20.0	45	1.330	5.3	19600
II	146	26.0	48	1.770	6.8	20956
III	163	32.0	50	1.760	5.5	27104
III	172	36.5	55	1.730	4.7	31427
III	172	37.0	55	1.750	4.7	33078
III	173	38.0	55	1.770	4.6	34200
III	174	37.5	55	1.750	4.7	35175
III	174	40.5	56	2.940	7.3	36774
III	175	41.0	56	3.080	7.5	37310
III	177	41.0	57	2.770	6.7	37474
III	178	42.0	58	2.870	6.8	38430
IV	170	43.0	56	2.870	6.7	40764
IV	180	44.0	60	3.240	7.4	42152
IV	182	48.0	60	3.320	6.9	49200
IV	182	48.0	63	3.900	8.1	60000
IV	182	48.0	60	3.280	6.8	51156
IV	183	48.0	60	3.470	7.2	52656
IV	184	48.0	60	3.485	7.3	55408
IV	184	48.5	60	3.550	7.3	57153
IV	185	48.5	60	3.580	7.4	57327
IV	186	50.0	65	3.495	7.0	61550
IV	190	53.0	60	3.390	6.4	65935
IV	190	56.0	65	3.425	6.1	71624
IV	192	57.5	65	3.520	6.0	74463
IV	192	59.0	67	3.670	6.3	75748
V	197	57.0	70	3.650	6.4	74043
V	213	65.0	70	3.590	5.5	82716
Mean	170.4	42.3	55.1	2.600	6.3	42739

B.

Age (years)	Length of fish (mm)	Weight of fish (g)	Length of ovary (mm)	Weight of ovary (g)	Gonadosomatic index	Fecundity 'F'
			NANGIGAR SPECIMENS			
II	125	17.0	35	0.820	4.8	11544
II	128	18.5	36	1.020	5.5	11797
II	136	20.0	40	1.210	6.1	15908
II	137	20.5	40	1.270	6.2	15524
II	140	22.0	42	1.330	6.0	17650
II	142	23.5	42	1.300	5.2	17675
II	144	23.0	43	1.250	5.4	17993
II	148	24.0	45	1.260	5.3	19252
II	150	24.5	46	1.350	5.5	19976
II	151	24.0	45	1.530	6.4	20164
II	153	28.5	48	1.650	5.8	23172
II	154	27.5	46	1.440	5.3	24600
III	157	29.0	47	1.600	5.5	26504
III	158	31.0	50	1.770	5.7	27948
III	163	34.0	50	1.850	5.4	29052
III	164	35.0	51	1.970	5.6	31738
III	165	36.5	50	2.020	5.5	32513
III	165	38.0	52	2.520	6.6	35846
III	166	40.0	58	2.190	5.5	38348
III	166	41.0	55	2.660	6.5	39050
III	170	42.0	55	2.720	6.5	40976
IV	173	43.5	56	2.520	5.8	43616
IV	178	43.0	57	2.450	5.7	43872
IV	186	48.0	61	2.840	5.9	48856
V	189	50.0	62	3.095	6.2	51704
V	190	52.0	62	3.170	6.1	51838
V	192	54.0	65	3.140	5.8	56826
Mean	159.0	33.0	49.2	1.930	5.8	30187

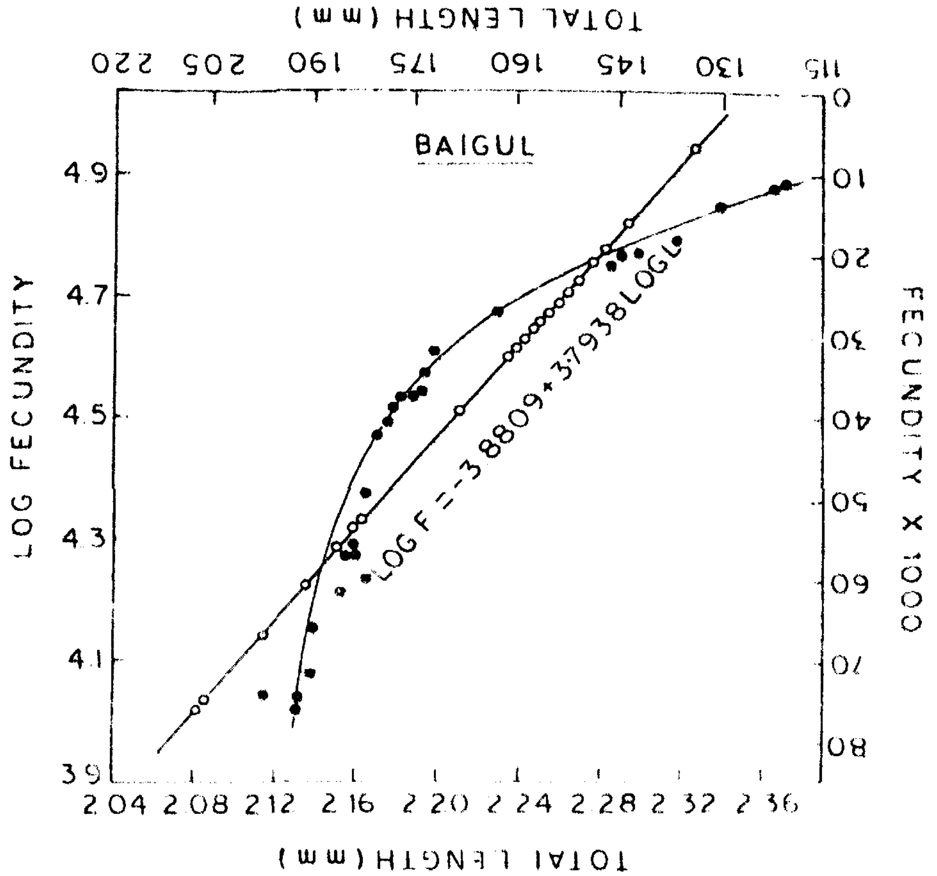
TABLE IX

Regression analysis of fecundity relations in [illegible]

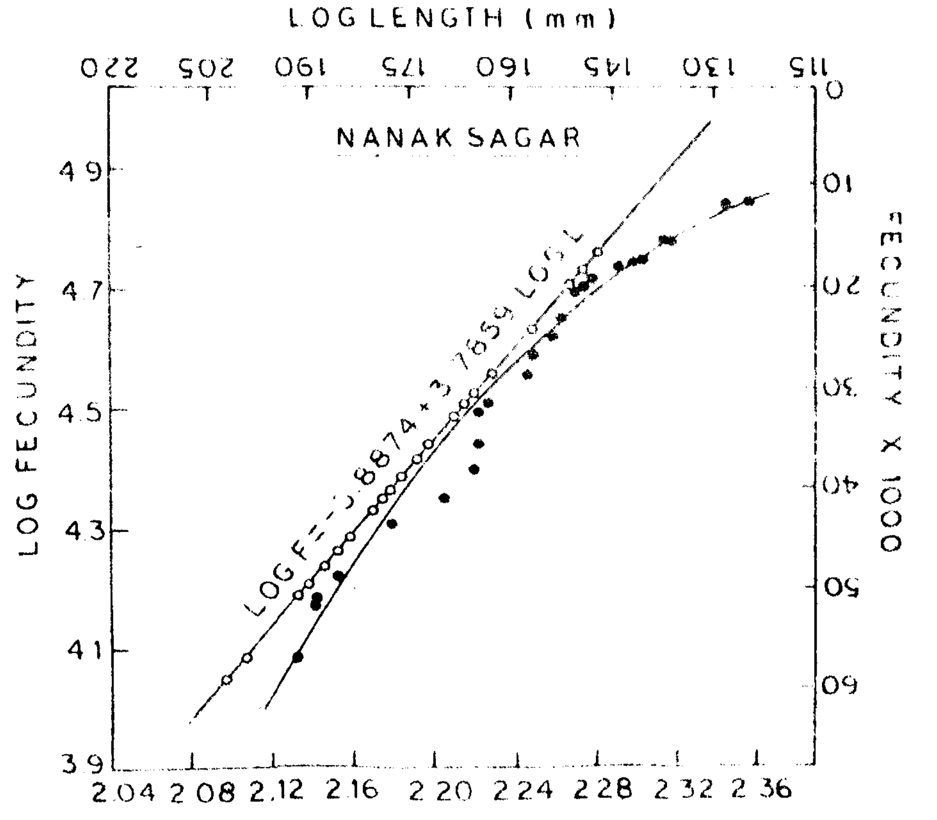
Number of observations	Parameters	Regression equations: Logarithmic	Regression equations: Parabolic	Correlation coefficient 'r'	Significance
		BAIGUL SPECIMENS			
55*	Body length 'L' vs Fecundity 'F'	Log F = − 5.8809 + 3.7938 Log L	$F = 0.1516 \times 10^{-5}\ L^{3.7938}$	0.97	$P < 0.001$
55	Body weight 'W' vs Fecundity 'F'	Log F = + 2.2733 + 1.4599 Log W	$F = 1.8765 \times 10^{2}\ W^{1.4559}$	0.99	$P < 0.001$
55	Ovary length 'OL' vs Fecundity 'F'	Log F = − 0.2816 + 2.7986 Log OL	$F = 0.5228 \times 10^{-0.0}\ OL^{2.7986}$	0.97	$P < 0.001$
55	Ovary weight 'OW' vs Fecundity 'F'	Log F = + 4.1574 + 1.1115 Log OW	$F = 1.4368 \times 10^{4}\ OW^{1.1115}$	0.95	$P < 0.001$
55	Age 'A' vs Fecundity 'F'	Log F = + 3.6377 + 1.8565 Log A	$F = 4.3429 \times 10^{3}\ A^{1.8565}$	0.95	$P < 0.001$
		NANAKSAGAR SPECIMENS			
27**	Body length 'L' vs Fecundity 'F'	Log F = − 3.8874 + 3.7857 Log L	$F = 0.1296 \times 10^{-3}\ L^{3.7859}$	0.95	$P < 0.001$
27	Body weight 'W' vs Fecundity 'F'	Log F = + 2.4009 + 1.3685 Log W	$F = 2.5171 \times 10^{2}\ W^{1.3685}$	0.99	$P < 0.001$
27	Ovary length 'OL' vs Fecundity 'F'	Log F = − 0.3685 + 2.8673 Log OL	$F = 0.3996 \times 10^{-0.0}\ OL^{2.8673}$	0.98	$P < 0.001$
27	Ovary weight 'OW' vs Fecundity 'F'	Log F = + 4.1252 + 1.2214 Log OW	$F = 1.3280 \times 10^{4}\ OW^{1.2214}$	0.98	$P < 0.001$
27	Age vs Fecundity	Log F = + 3.8642 + 1.3077 Log A	$F = 7.3147 \times 10^{3}\ A^{1.3077}$	0.91	$P < 0.001$

* D.F. = 53   ** D.F. = 25

Fig. 1. Relationship between total length and fecundity of *G. chapra* (●——●, parabolic; O——O, logarithmic).

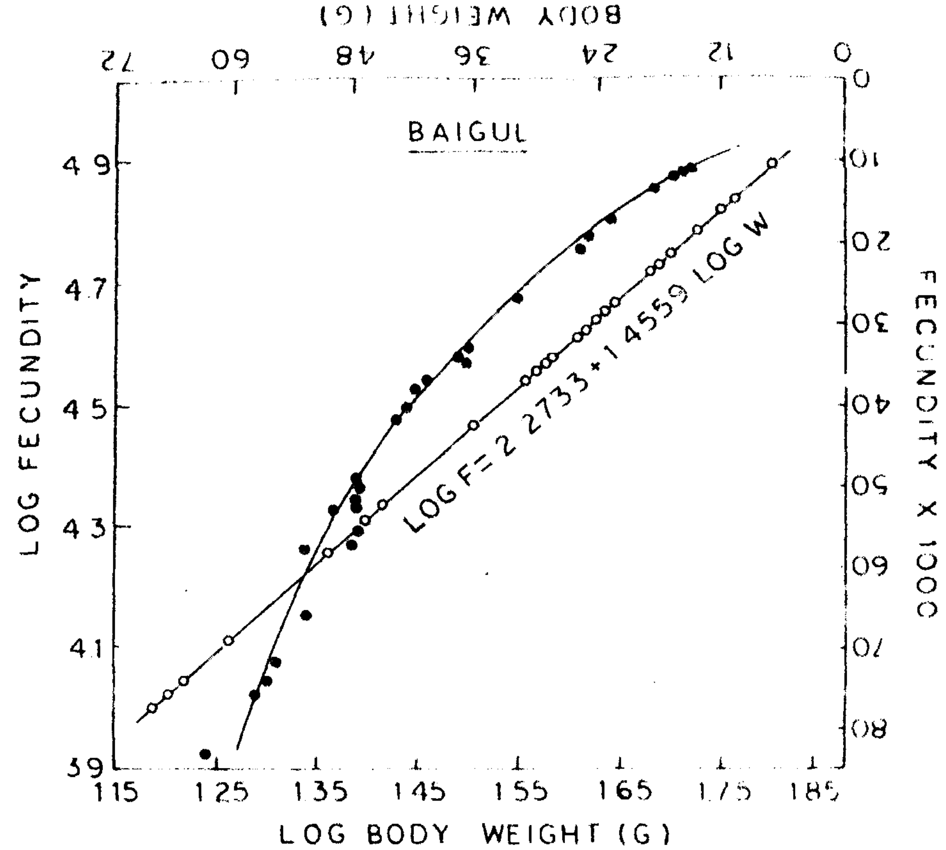


TOTAL LENGTH (mm)
BAIGUL
LOG F = -3.8809 + 3.7938 LOG L
LOG FECUNDITY
FECUNDITY X 1000
TOTAL LENGTH (mm)

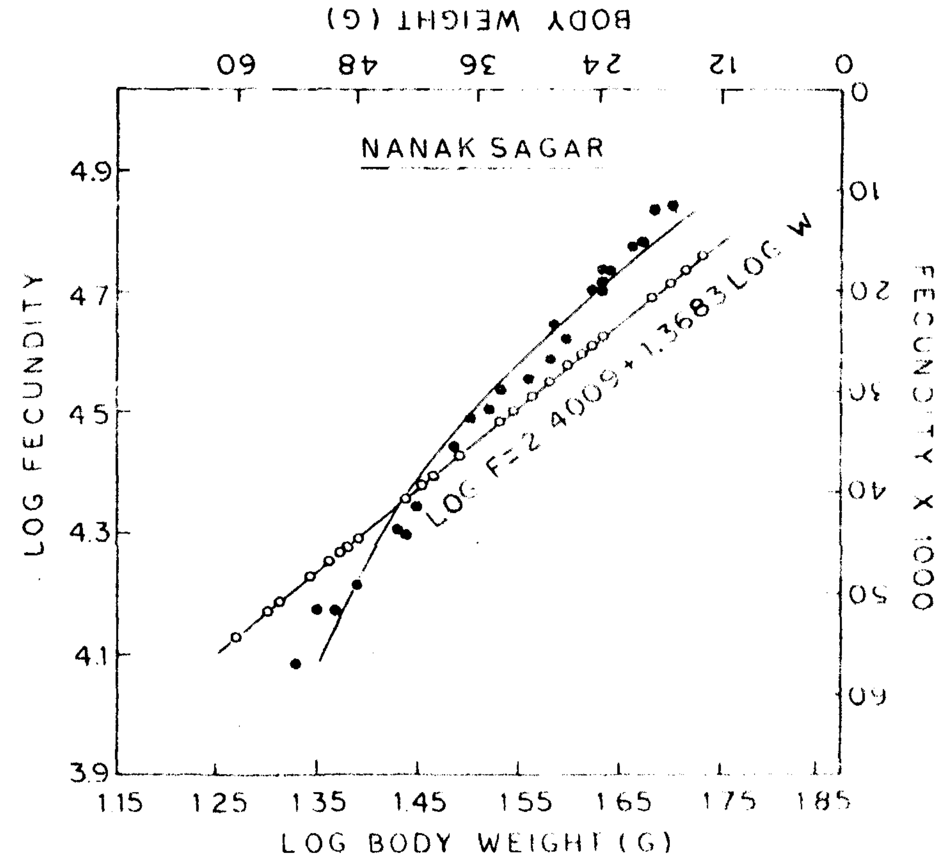


LOG LENGTH (mm)
NANAK SAGAR
LOG F = -3.8874 + 3.7659 LOG L
LOG FECUNDITY
FECUNDITY X 1000
LOG LENGTH (mm)

Fig. 2. Relationship between body weight and fecundity of *G. chapra* (●——●, parabolic; O——O, logarithmic).

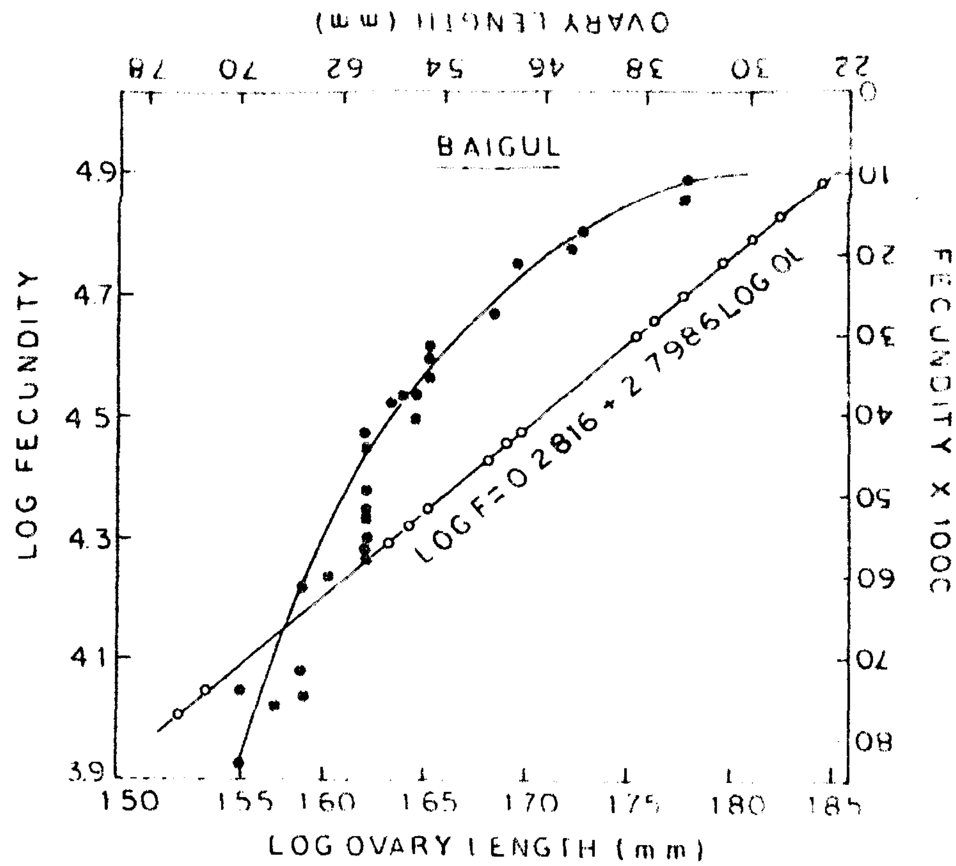


BODY WEIGHT (G)
BAIGUL
LOG FECUNDITY
FECUNDITY X 1000
LOG F=2 2733+1 4559 LOG W
LOG BODY WEIGHT (G)



BODY WEIGHT (G)
NANAK SAGAR
LOG FECUNDITY
FECUNDITY X 1000
LOG F=2 4009+1.3683 LOG W
LOG BODY WEIGHT (G)

Fig. 3. Relationship between ovary length and fecundity of *G. chapra* (●——●, parabolic; O——O, logarithmic).


BAIGUL
LOG FECUNDITY
LOG OVARY LENGTH (mm)
OVARY LENGTH (mm)
FECUNDITY X 1000
LOG F = 0 2816 + 2 7986 LOG OL

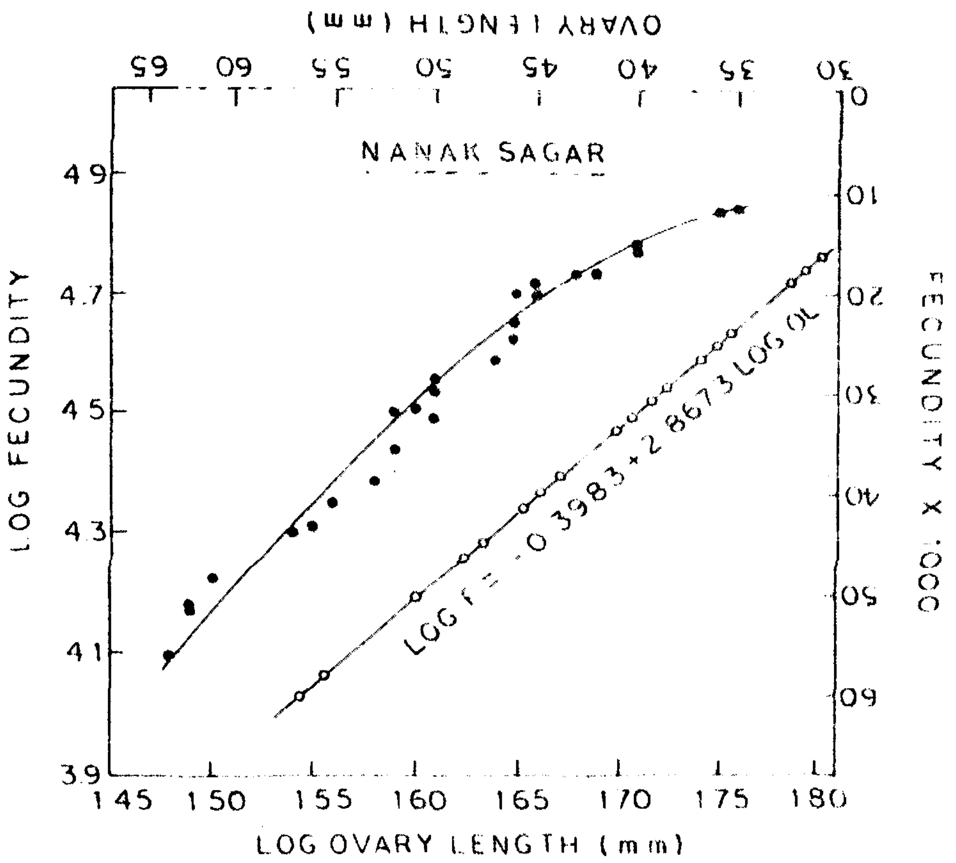
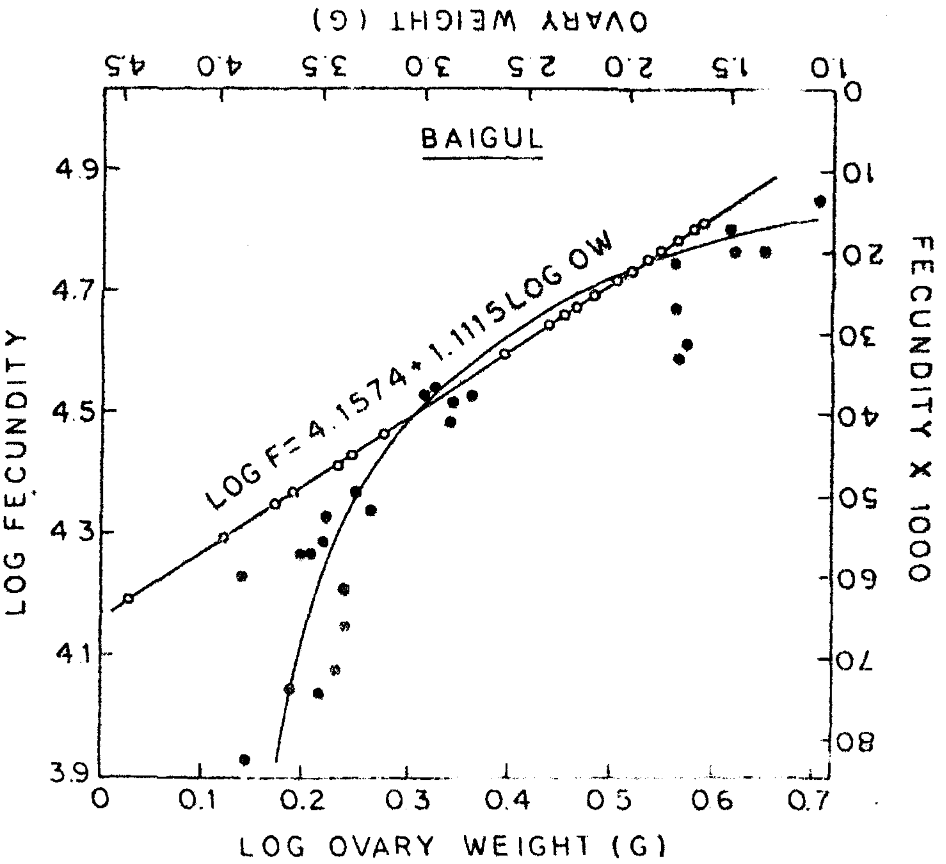

NANAK SAGAR
LOG FECUNDITY
LOG OVARY LENGTH (mm)
OVARY LENGTH (mm)
FECUNDITY X 1000
LOG F = -0 3983 + 2 8673 LOG OL

Fig. 4. Relationship between ovary weight and fecundity of *G. chapra* (●——●, parabolic; ○——○, logarithmic).


BAIGUL
LOG F= 4.1574 + 1.1115 LOG OW
LOG FECUNDITY
FECUNDITY X 1000
LOG OVARY WEIGHT (G)
OVARY WEIGHT (G)

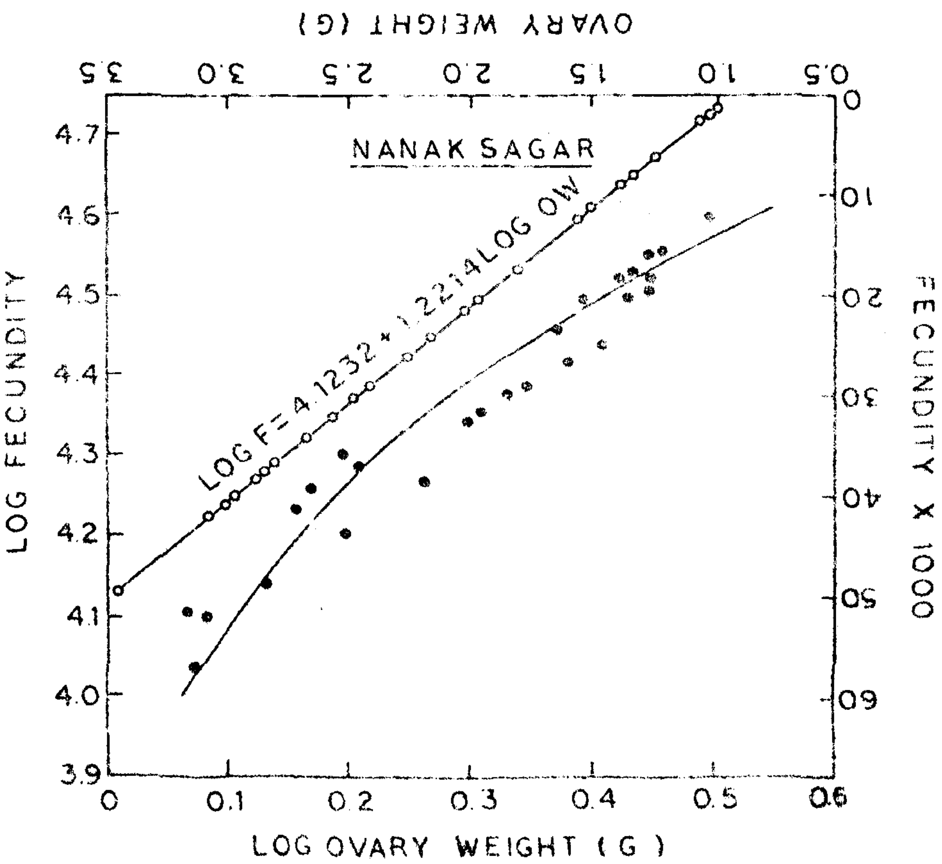
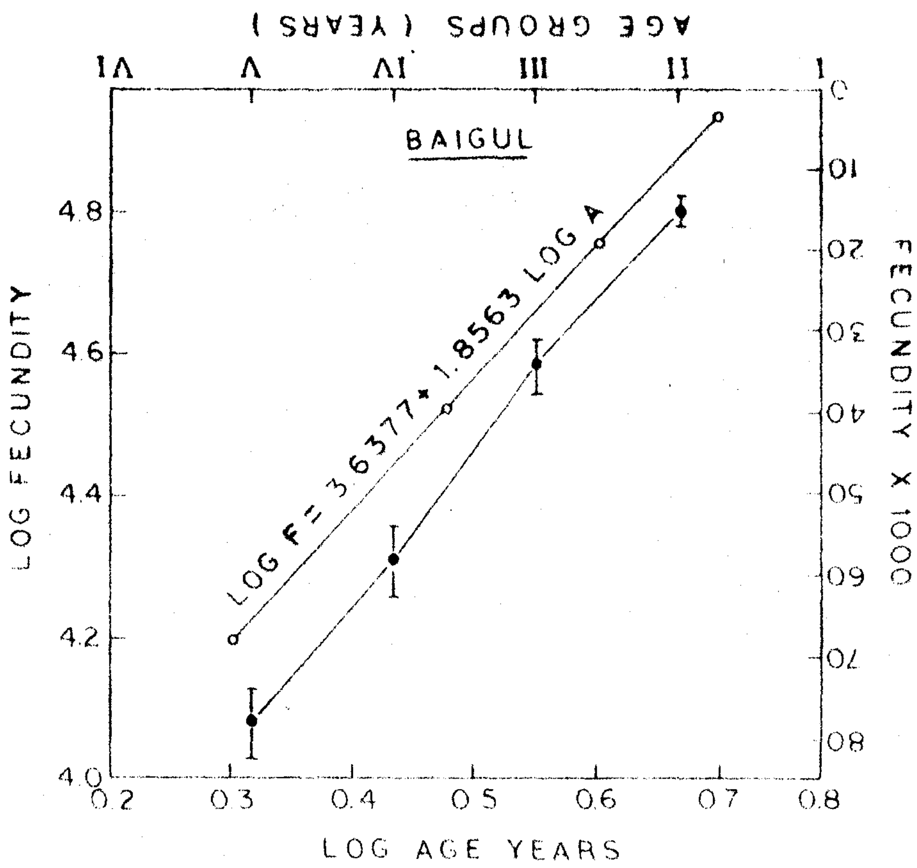
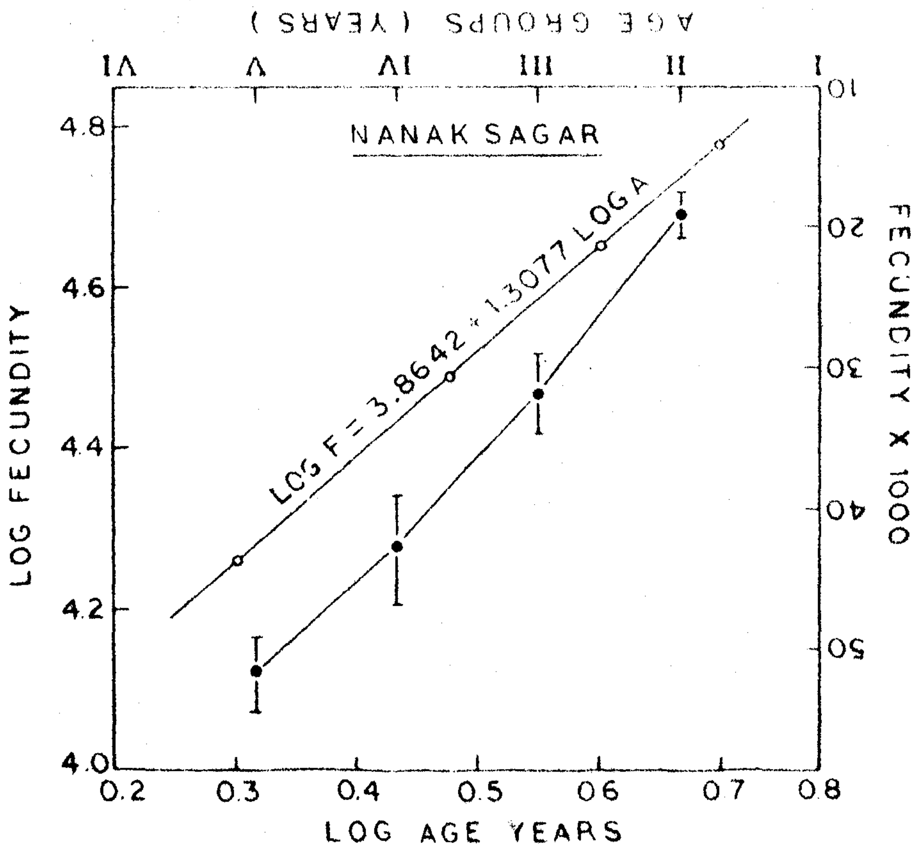

NANAK SAGAR
LOG F= 4.1232 + 1.2214 LOG OW
LOG FECUNDITY
FECUNDITY X 1000
LOG OVARY WEIGHT (G)
OVARY WEIGHT (G)

Fig. 5. Relationship between age and fecundity of *G. sharra* (●——●, parabolic; O——O, logarithmic.



AGE GROUPS (YEARS)
BAIGUL
LOG F = 3.6377 + 1.8563 LOG A
LOG FECUNDITY
FECUNDITY X 1000
LOG AGE YEARS



AGE GROUPS (YEARS)
NANAK SAGAR
LOG F = 3.8642 + 1.3077 LOG A
LOG FECUNDITY
FECUNDITY X 1000
LOG AGE YEARS

P A R T   IV

FISHERY POTENTIAL AND MANAGEMENT OF BAIGUL RESERVOIR

Studies on fisheries and management of lacustrine environments yield information on fishing pressure, species frequencies, efficiency of gears used, quality of fisheries, composition of catch and stock and the changes in fishery with time (Muish, 1971). According to Jhingran (1982) the statistical record of fish landings are of paramount importance in rational exploitation of the renewable biological resources. The immediate objective of any such study is believably the prediction of fish production and assessment of harvest potential.

Nikolskii (1980) has explained at length the importance of rational fishery based on three criteria, viz., 1) extraction from a stretch of water (or exploitable population) of the maximum output of the highest quality, 2) extraction with minimum cost in labour and materials, 3) reproduction of the population at a high level such as to permit regular intensive exploitation. Through scientific management level of fishing can be adjusted by exercising control on the magnitude of the landings, zones fished, and taking up artificial cultivation if it proves feasible. Regulation of fishery in fact improves the conditions of life, enabling increased multiplication and faster growth. The circumstances demand that human beings must change their attitude of hunting and self centered food gathering to cultivation and management of the food resources. This is undoubtedly a guide to our progress. The prevailing food crisis and particularly protein deficiency is not the consequence of the exhaustion of the biosphere exclusively but the economic mismanagement is the main causative factor.

The potential of reservoirs calls for immediate steps to augment production and yield. It is for this reason that the Baigul reservoir was surveyed and a wide variety of data collected. It is hoped the information embodied herein will provide a framework for purposeful formulation of fisheries policy by resource managers.

Data given in Tables I-VI and Figs. 1-5, pertaining to monthly and annual catches, expenditure, revenue, water level, catch per unit effort and stocking rate were obtained from the office of Assistant Director of Fisheries, Haldwani (District Nainital). The data were recalculated wherever deemed necessary to maintain standard of accuracy. Information on terms and conditions of the contract was also collected from the same source. However, for analysis of monthly size frequency distribution of Gudusia chapra 2154 specimens were procured randomly over a period of 9 months (1977-78) from the commercial catches at the Baigul Fishing Center, popularly referred to as 'Machhalijhala'. This information is presented in Table VI, Fig. 6. Specimens of G. chapra were divided into five groups with 35 mm class interval and the relative percentages of different size groups calculated. Table VII, Fig. 7 indicate monthly fluctuations in average landings of this species. Measurements of different gears used in this reservoir for the harvest of different species were recorded personally by the author. Socio-economic condition of fishermen was assessed by personal observations and frank discussion with them over a period of 15 months.

Daily catches from the Baigul reservoir comprised of the following species of teleosts: *Gudusia chapra*, *Labeo rohita*, *Labeo calbasu*, *Labeo bata*, *Labeo gonius*, *Catla catla*, *Cirrhina mrigala*, *Cirrhina reba*, *Puntius sarana*, *Puntius stigma*, *Puntius ticto*, *Cyprinus carpio*, *Ompok bimaculatus*, *Oxygaster bacaila*, *Amblypharyngodon mola*, *Chanda nama*, *Chanda ranga*, *Nandus nandus*, *Xenentodon cancila*, *Mystus seenghala*, *Mystus vittatus*, *Wallago attu*, *Notopterus notopterus*, *Mastacembelus armatus*, *Channa punctatus*, *Channa striatus*, *Channa marulius*.

For marketing purpose six major categories are customarily made by the Fisheries Department of Uttar Pradesh.

Category 'A': Includes carps, *Labeo rohita*, *Labeo calbasu*, *Cirrhina mrigala*, *Catla catla*, *Cyprinus carpio* and hybrids of these species, above 1½ kg individual weight.

Category 'B': All fishes of category 'A' below 1½ kg.

Category 'C': Wallago attu, Mystus spp., Channa spp. Cirrhina reba, Puntius sarana, Mastacembelus armatus, Ompok bimaculatus.

Category 'E': Gudusia chapra, Amblypharyngodon mola and other small-sized fishes not included in any of the above categories.

Category 'F': Shrimps.

Periodic fluctuations in fish catches are usually related to general climatic causes, but in several cases size of landings bears a non-periodical character and appears to be determined by local phenomena. Factors such as draught, untimely floods, predation, excessive mortality of fish seed, loss of fishing grounds, decline in fishing efforts have been identified by several authors (Chakraborty,& Singh, 1963; Banerji & Chakraborty, 1969; Pradhan, 1956; Muddanna & Chandrasekharan, 1973; Jhingran, 1982) as reasons for poor catch of mostly endemic (confined) species. Marked variations, annual as well as monthly, in the fishery of various species of Baigul reservoir are noticeable.

Stocking rate of fingerlings

The stocking rates and ratios of the fingerlings of various species of cultivable fishes are summarized in Table III. The practice of stocking was initiated in 1971-72 and fingerlings of *Labeo rohita*, *Labeo calbasu*, *Cirrhina mrigala*, *Catla catla* totalling 78025 were introduced in the reservoir. Thereafter, 24600, 24000, 69960, 113850, 210316 fingerlings were stocked in the years 1972-73, 1973-74, 1974-75, 1975-76 and 1976-77, respectively. *Cirrhina mrigala* was stocked at higher rate every year, followed generally by *Labeo rohita*, and *Labeo calbasu*. Seeds of *Catla catla* were released in the reservoir only in 1971-72 and 1976-77 and those too in smaller proportion (1% in 1971-72 and 2.4% in 1976-77). The stocking rate of miscellaneous species was quite variable (6.0 - 52.6% of the total in years 1974-75 to 1976-77).

On comparison of the rate of stocking with the annual crop of different species it became quite evident that in some fishes the magnitude of the yield was commensurate with the numerical strength of their seed, but exceptions did exist. The lowest yield of *Catla catla* was due to its very little stocking rate, a better but not a good output of marketable *Labeo rohita* was a consequence of moderate abundance of its seeds released in the reservoir, but the catch of *Cirrhina mrigala* was hopelessly poor despite its maximum stocking density, whereas a fairly high landing of *Labeo calbasu* was obtained despite its poor stocking.

Catch-effort statistics

Table IV provides an account of fish landings calculated on the basis of full sluice level (F.S.L.) area as well as average level (A.L.). The trend was such that the per hectare yield on F.S.L. was distinctly higher than the same on A.L. area after year from 1970-71 through 1977-78. From 1970-71 the F.S.L. and A.L. catch increased spectacularly in successive periods upto 1973-74 whence it peaked and wentdown appreciably in 1974-75 only to recover next year all the way upto 1977-78, the last of the recorded fiscal years. Catch-effort data were procured for the years 1972-73 to 1976-77. Number of fishing days, fishermen employed and boats used in the fishing operations varied yearly. No appreciable difference was seen in either catch/man effort or catch/boat effort in the various years. In either of the two sets of the data annual catch was close to its own average. Yearwise catch/day, however, seemed to fluctuate, sometimes notably, the highest being in 1973-74.

Fishing gears used

Eight types of fishing gears are operated in the Baigul reservoir.

(i) Gill net (Phansi jal): These are drift gill nets knitted of nylon thread. Each piece is usually 25-35 ft long. Breadth is also variable (65 - 117 cm). The mesh size (in extended net measures variously: 2, 4, 6, 6.5, 7.0, 7.5, 8.0, 9.0, 9.5, 10 cm). A thick cord runs lengthwise on one side only.

During the operation floats are tied to the cord and weights (mostly stone pieces) to the other cord-free end. Usually 5-8 net pieces are knotted together end to end and each assembly in handled by fishermen from a small boat locally called as 'kashti' or 'Dongi'. The gears are very successful for catch return of *Labeo rohita*, *Labeo calbasu*, *Labeo gonius*, *Cirrhina mrigala*, *Catla catla*, *Cyprinus carpio*, *Mystus aenochala*, *Wallago attu*, *Channa striatus*, *Channa marulius* and *Notopterus notopterus*.

(2) *Boat seive lift bag net* (Long Bisari): This net which is made up of nylon or yarn has two parts: a triangular wing and a bag. Front and lateral sides of the wing are tied to cord and held on frame of crossed bamboo bars of moderate diameter, fitted to one end of the boat. The bag is situated on extreme posterior side, facing the boat. Length of the net with the bag varies from 15 to 20 ft and mesh size is 0.8 cm. At least 4 boats and 8 fishermen (2 on each boat or kashti) engage in the fishing operation. The boats form two pairs about 25 ft apart. Fishermen of opposite boats produce artificial sound usually by drum beating and proceed towards the boats fitted with the net. Schools of fishes are driven to the net as the sounding boats move towards the two stationed boats. The fishermen on board these boats close on and relax the cross bamboo pillars alongwith the net, 2-3 ft or more deep in the water. The entire operation lasts about 15 minutes

after which the net alongwith catch is handled and fishes transferred to the bag and finally emptied into the boat. This method is employed mainly for Gudusia chapra, Amblypharyngodon mola, Puntius ticto, Puntius stigma, Oxygaster bacaila, Chanda nama, Chanda ranga. Some other small-sized species including Labeo gonius and Cirrhina reba are also caught.

(3) Scoop net (Haluka): This is a rectangular type of seine net with small mesh (0.5 cm), made up of either nylon or yarn thread. It is operated for shrimps mainly during summer season. A nylon cord runs along the border of four sides and from each corner of the net extends a long cord which is knotted to bars of curved and crossed bamboo frame. The cross point of the two bars are fastened with the help of a small piece of rope. A fisherman holds the frame, dips it in the shallow water and drags slowly against the direction of current. After 10-15 minutes the gear is hauled up and shrimps collected.

(4) Cast nets (Jhinguri): The net is conical and made up of nylon or yard thread, with mesh of various grades: 2.0, 2.5, 3.0, 5.0 cm. It has two parts, rope end (apical part) and bottom (basal) one. The apical end is tied to a rope of 4-6 ft, while the margin of basal part is fastened with cord from which hand the various weights in the form of little balls of

iron or lead. One fisherman hold the rope in one hand and by the other hand revolves the net in a circle before casting it in the water. The weights carry the net deeper in the water. Net is then draged for some distance before its mouth is shut off by the cord regulated by the fisherman, before being lifted up. Cast net is generally operated in summer (premonsoon period). Carps and catfishes are usually caught by this method.

(5) Conical basket net (Tapar): This net of 5-6 ft height and 4-8 cm mesh size is operated only occassionally during summer. The two ends (apical and basal) are always open during and after the operation. A bamboo frame supports the net. The size of apical part (mouth) is almost half the size of basal part and the net then assumes the shape of a conical basket. Two or three fishermen hold the frame and dip the net in water. Fishes enter through the mouth and are accomodated in the basal bag. *Labeo rohita*, *Labeo calbasu*, *Labeo gonius* and *Mystus* spp. are usually caught by this gear.

(6) Hooks and long line gear: This long line gear is a modification of monothread hand line made up of nylon. There is a strong horizontal main line to which are attached small lines numbering about 8-10. Each line ties a baited hook. Few floats are connected with the lines. Fishermen on board a small boat carry out the fishing. Forage fishes (*Amblypharyngodon mola*, *Puntius stigma*, etc.) and crustaceans

serve as baits. Carnivorous fishes like *Mystus seenghala*, *Mastacembelus armatus*, *Channa punctatus*, *Channa striatus*, *Channa marulius* and *Wallago attu* of all sizes and weight classes are caught.

(7) Spear gear: It is a simple harpooning device operated rarely. The gear consists of two parts, a stout handle and a sharp-edged curved blade. The gear is operated in clear and shallow water for large-sized *Wallago attu* and *Mystus* spp. Only with exact aiming and timing a fisherman gets one or two specimens in a day but usually draws blank.

(8) Hand seine net (Small bisari): It is a simple triangular hand seine net operated by single person in shallow waters. the net is dipped in water and moved forward. The architecture is the same as that of boat seine. However, net size is small but variable and mesh measures 0.5 cm. Used mainly for shrimps but many small sized fishes of poor market value also got caught.

Staff of Fisheries Department

The administrative hierarchy of Uttar Pradesh Fisheries Department comprises of one Director of Fisheries (DF) in the Directorate Head Quarter at Lucknow. There are seven Deputy Directors of Fisheres (DDF). One in the Head Quarter and the remaining for Agra, Jhansi, Varanasi, Bareilly, Lucknow-Faizabad, Lucknow-Farrukhabad divisions. For better administrative grip each Division is sectored into subdivisions and the different subdivisions are manned by different Assistant Directors of Fisheries (ADF). One ADF looks after 2-3 reservoirs, depending upon the magnitude of landings and work load. Working under ADF of each Division are Senior Fisheries Inspectors(SFI), one for every reservoir or lake. The SFI is answerable to ADF for matters related to the center where the personnel is posted. For round the clock spot inspection the SFI is assisted by one Fisheries Inspector (FI) and two Assistant Fisheries Inspectors (AFI). Fishermen number is variable. They are either permanent recruits or daily wagers.

The hierarchy is summarised below:

- DF (Lucknow)
  - DDF (Divisions)
    - Agra
    - Jhansi
    - Varanasi
    - Bareilly
      - ADF (Subdivision)
        - SFI (For a reservoir/lake)
          - FI (One)
          - AFI (two)
          - Fishermen (No. variable)
    - Lucknow-Faizabad
    - Head Quarter Lucknow
    - Lucknow-Farrukhabad

<u>Job assignments of the staff:</u>

Duties of the staff of the Baigul reservoir are: to maintain daily limnological records; to check the exploitation of the major carps below $1\frac{1}{2}$ kg; to maintain fish landing records on day to day basis (Category wise and species wise); to check the illegal fishing especially during night time and in remote places of the reservoir day and night; to carry out stocking of the seeds of economically important fishes, to manage the transport of iced catch to Bariellly and Nanital fish markets; to deal with contractors and those entrusted with wholesale and to see that fishes are sold at reasonable rates; to maintain accounts of investment and earning; to furnish the revenue to the competent authority.

The Baigul fishing center at present has only one control room of its own while main office complex with staff quarters, 6-7 km away, are on Irrigation Department's lease.

Terms and Conditions of tender and contract:

The DF (Lucknow) is authorised to accept or cancel the tender without assigning any reason. The contractor must accept the rates fixed by DDF for the purchase of fishes of different categories: A, B, C, D, E, F. The contractor is required to make the payment in cash or by cheque in the name of DDF within 15 days of the tender-date. Security money of contractor is forfeitted if he fails to honour the agreement. However, if DDF is satisfied with contractors problems and the cancellation of the bargain is not likely to hit the revenue, he can recommend release of the security after 6 months of the expiry date of the contract. If the contract materializes, the contractor is required to deposit in advance certain amount fixed by the DOF before the commencement of the fishing operations. If during the progress of fishing the contractor recovers the investment through catch then he is directed to complete the agreed payment and seek clearance for further fishing in the on-season. The contractor is warned to use gears that provide for the escapement of smaller fishes which have not attained the stipulated marketable size. On inadvertent capture of those fishes, the contractor is advised to release them back to the reservoir. Non-adharence of this code of conduct makes the contractor liable to penalty fixed by the DOF.

Fishermen cooperative society and private contracts:

The state Fisheries Department established a fishermen cooperative society aimed at improving the socio-economic condition of the poor local fishermen. The society is constituted of 20-25 members representing the fisherfolk community. But this society seems to exist only on paper. The fishing rights are officially given to this so-called society and the rules and regulations issued. The 'Secretary' of the society is delegated with the power to giving out the contract. A contractor from the private sector enters a deal with the (Secretary) of the Society for fishing. After the contract is signed preparations for large-scale fishing start. These include the procurement of fishing boats, nets and hirement of fishermen. The 'Secretary' maintains all records relevant to fishing activity and issues the cash memo slips bearing his signature, to the contractor in a way that on paper the contractor owns fishing rights from the Society. When fishing season is over, the contractor offers bonus to all members of the so-called society, including 'Secretary' besides meeting their boarding, lodging or the darness allowances. Infact, it seems the 'Secretary' and Society are hired by the contractor for processing the paper formalities, with no real authority vested in them.

Socio-Economic Conditions of Fishermen:

During the fishing season local professionals and fishermen from Bijnore district of Uttar Pradesh and from several parts of Bihar approach the contractor for seasonal employment. When bargain is settled the fisherfolk seek from the contractor the hutments or any type of shelter close to Baigul. Most of the fishermen hail from villages and leave their families behind. The families may join them for certain parts of the season. Fishes and rice form the bulk of their dietary. The side business of these employees runs in their native places. The net saving from fishing profession varies from Rs. 1000 - 2000 per man for the season. Generally Bijnori fishermen are better off than the Biharis. Bihari fishermen are traditionally engaged in fishing for *G. chapra* whereas those from Bijnore have the necessary know-how of operating the various types of nets for other fishes and shell fishes.

Annual revenue and expenditure:

The investment and earning figures (Table I) indicate that Baitul reservoir sustains fisheries of considerable economic value, since the output fairly exceeds the input. From 1970-71 to 1974-75, expenditure maintained on upward trend, and the revenue responded to it, showing remarkable success of fishing strategy. A decrease in the revenue in 1974-75 despite a slight increase in expenditure was so marginal as to be of no consequence in large-scale fishing. What is worthy of consideration is the appreciable increase in the revenue despite substantial decline in the expenditure in 1975-76. This confirms the rational management and exploitation of the resources and signifies that efforts are fruitful. The trend could not be further analysed because expenditure-revenue figures for 1976-77 were unobtainable. *G. chapra* yields maximum revenue to the Fisheries Department almost every year despite its low market value compared to major carps, catfishes and murrels.

RECOMMENDATIONS

Based on the above observations and critical analysis of the data following suggestions can be made for better management and exploitation of fishery resources in the Baigul reservoir.

(1) Wooded plants and other obstacles should be removed from the reservoir basin to facilitate the fishing operations.

(2) Physico-chemical conditions of water in the reservoir as well as in the river 'Sukhi'/'Baigul' which constitutes the main supply line should be regularly monitored.

(3) A record of plankton be made and measures adopted for increasing their productivity commensurate with the requirements of stocked fishes.

(4) Cultivation of certain quickly harvestable legumes in shore areas which get exposed in summer due to fall in water level may be encouraged. The leguminous crop will be helpful in nitrogen fixation in the soil. Besides, its top cuttings will be supplied as badly needed green fodder. The crop remains will also manure the soil.

(5) Fishing off-season declared from July to September should be advanced by one month i.e., from June to September, to check the exploitation of brood fish. This will ensure proper recruitment.

(6) Fishing in the reservoir should be rationalized by systematic removal of predatory fishes which take a heavy tool of commercially important species. Trash fish which too are in abundance and compete with economical varieties, need eradication.

(7) Stocking ratios of compatable species be revised and its effect on landings and revenue recorded.

(8) Unwanted rooted vegetation infesting the reservoir be replaced by useful hydrophytes such as Hydrilla.

(9) New and more efficient models of the nets be introduced for commercial fishing.

(10) Whatever fisheries legislations have been enacted by the Government should be implemented strictly.

(11) Extension services should be extended to fisherfolk and local population for making them see reason for rational exploitation and acquaint them of the consequences of indiscriminate capture on their own socio-economic condition.

TABLE - I

Annual catch of Baigul reservoir, expenditure and revenue

Year	Total catch (kg)	Total catch (category wise) with percentage						Expenditure (Rs)	Revenue (Rs)
		A (kg)	B (kg)	C (kg)	D (kg)	E (kg)	F (kg)		
1970-71	22659.5	1813.7 (8.0%)	261.0 (1.2%)	5672.1 (25.0%)	14902.7 (65.8%)	-	-	13986.11	41161.76
1971-72	40571.8	1765.0 (4.4%)	561.9 (1.4%)	20378.9 (50.2%)	17866.0 (44.0%)	-	-	34765.21	65915.27
1972-73	104831.1	8082.4 (7.7%)	386.2 (0.4%)	39702.6 (37.9%)	44356.0 (42.3%)	12082.4 (11.5%)	221.5 (0.2%)	163404.96	138280.00
1973-74	154653.5	9348.3 (6.0%)	623.5 (0.4%)	33170.4 (21.5%)	44383.9 (28.7%)	67127.4 (43.4%)	-	90350.47	229374.00
1964-75	105336.6	12044.6 (11.4%)	1151.3 (1.1%)	20674.6 (19.6%)	26129.8 (24.8%)	44561.8 (42.3%)	774.5 (0.8%)	91374.16	226400.00
1975-76	106800.0	11096.8 (10.4%)	1110.8 (1.0%)	32692.8 (30.6%)	18121.6 (17.0%)	19737.2 (18.5%)	24040.8 (22.5%)	50134.17	245973.00
1976-77	119762.1	16925.9 (14.1%)	1234.3 (1.0%)	28423.4 (23.7%)	20940.8 (17.5%)	50242.2 (42.0%)	1995.5 (1.7%)	-	217029.00
1977-78	156025.4	-	-	-	-	-	-	-	214537.71
Mean	101328.7	8725.2	761.3	25816.4	26671.5	38750.2	6760.57	87269.18	172331.34

TABLE - II

Monthly variation in the total catch and revenue.

Years	Months	Catch (kg)	Revenue (Rs)
1977	April	10147800	14337.25
"	May	19562900	31167.20
"	June	20374300	20205.19
"	July	-	23049.03
"	August	-	-
"	September	-	-
"	October	22009000	12000.00
"	November	26968600	45000.00
"	December	17953300	25000.00
1978	January	13635100	15354.85
"	February	12763200	7397.11
"	March	12611200	21027.08
	Total	156025400	214537.71
"	April	18644300	16193.28
"	May	12019100	26438.83
"	June	13329600	20154.35
	Total	43993000	62786.46

TABLE - III

Annual variation in water level and rate of fingerlings stocking

Year	Water level (ft)		Fingerling Stocking					
			No. of Fingerling stock	% composition of different species				
	Highest	Lowest		*L. rohita*	*C. mrigala*	*C. catla*	*L. calbasu*	Others
1970-71	680.64	670.97	-	-	-	-	-	-
1971-72	682.23	668.91	78025	25.0	70.0	1.0	4.0	-
1972-73	680.77	668.95	24600	30.00	65.00	-	5.0	-
1973-74	679.67	667.15	24000	20.0	80.0	-	-	-
1974-75	678.72	667.15	63960	18.0	75.0	-	1.0	6.0
1975-76	680.93	666.66	113850	15.7	12.2	-	19.5	52.6
1976-77	681.67	666.03	210316	17.5	11.6	2.4	17.6	50.9

TABLE - IV

Annual variation in landings and catch-effort analysis

Year	Average production (kg/hect.)		No. of fishing days	No. of fishermen employed	No. of boats	Catch/Man (kg)	Catch/Boat (kg)	Catch/Day (kg)
	F.S.L.	A.L.						
1970-71	9.99	15.96	-	-	-	-	-	-
1971-72	17.9	28.6	-	-	-	-	-	-
1972-73	46.3	73.9	249	12212	5747	8.58	18.24	421.01
1973-74	68.3	109.0	275	18461	6601	8.38	17.98	562.37
1974-75	46.5	74.2	232	13457	5895	7.83	17.87	454.04
1975-76	47.2	75.3	258	12993	5713	8.22	18.69	413.95
1976-77	52.87	84.4	195	18656	7172	6.42	16.70	614.16
1977-78	68.88	110.0	-	-	-	-	-	-
Mean	44.7	71.4	241.8	15156	6625	7.87	17.9	493.1

TABLE - V

Annual yield of commercial species and their percentage composition
(Percentage values given in parenthesis)

Different species	YEARS				
	1972-73 (kg)	1973-74 (kg)	1974-75 (kg)	1975-76 (kg)	1976-77 (kg)
G. chapra	10483.10 (10.0%)	63407.90 (41.0%)	40027.20 (38.0%)	19224.00 (18.0%)	47066.50 (39.3%)
L. rohita	6289.86 (6.0%)	7732.67 (5.0%)	9164.30 (8.7%)	8010.00 (7.5%)	13772.60 (11.5%)
L. gonius	12579.70 (12.0%)	13918.80 (9.0%)	7373.56 (7.0%)	9184.80 (8.6%)	11137.90 (9.3%)
L. calbasu	1362.80 (1.3%)	2319.80 (1.5%)	3897.45 (3.7%)	3844.80 (3.6%)	5149.77 (4.3%)
P. sarana	9434.80 (9.0%)	7732.67 (5.0%)	6320.15 (6.0%)	5874.00 (5.5%)	3952.15 (3.3%)
N. notopterus	16773.00 (16.0%)	12372.30 (8.0%)	7373.56 (7.0%)	6621.60 (6.2%)	6826.40 (5.7%)
M. seenghala	14676.35 (14.0%)	13918.80 (9.0%)	8425.90 (8.0%)	9612.00 (9.0%)	7545.00 (6.3%)
W. attu	17821.30 (17.0%)	14692.10 (9.5%)	9058.90 (8.6%)	8010.00 (7.5%)	10060.00 (8.4%)
Channa spp.	8386.50 (8.0%)	9279.20 (6.0%)	7373.56 (7.0%)	6408.00 (6.0%)	7904.30 (6.6%)
C. mrigala	209.66 (0.2%)	463.60 (0.3%)	210.67 (0.2%)	320.40 (0.3%)	239.50 (0.2%)
Misc. Fish	6604.36 (6.3%)	8815.25 (5.7%)	5266.80 (5.0%)	5660.40 (5.3%)	4191.70 (3.5%)
Shrimps	209.66 (0.2%)	- -	842.70 (0.8%)	24030.00 (22.5%)	1916.90 (1.6%)

TABLE - 11

Relative abundance of different size groups of *G. chapra* (Percentage values given in parentheses)

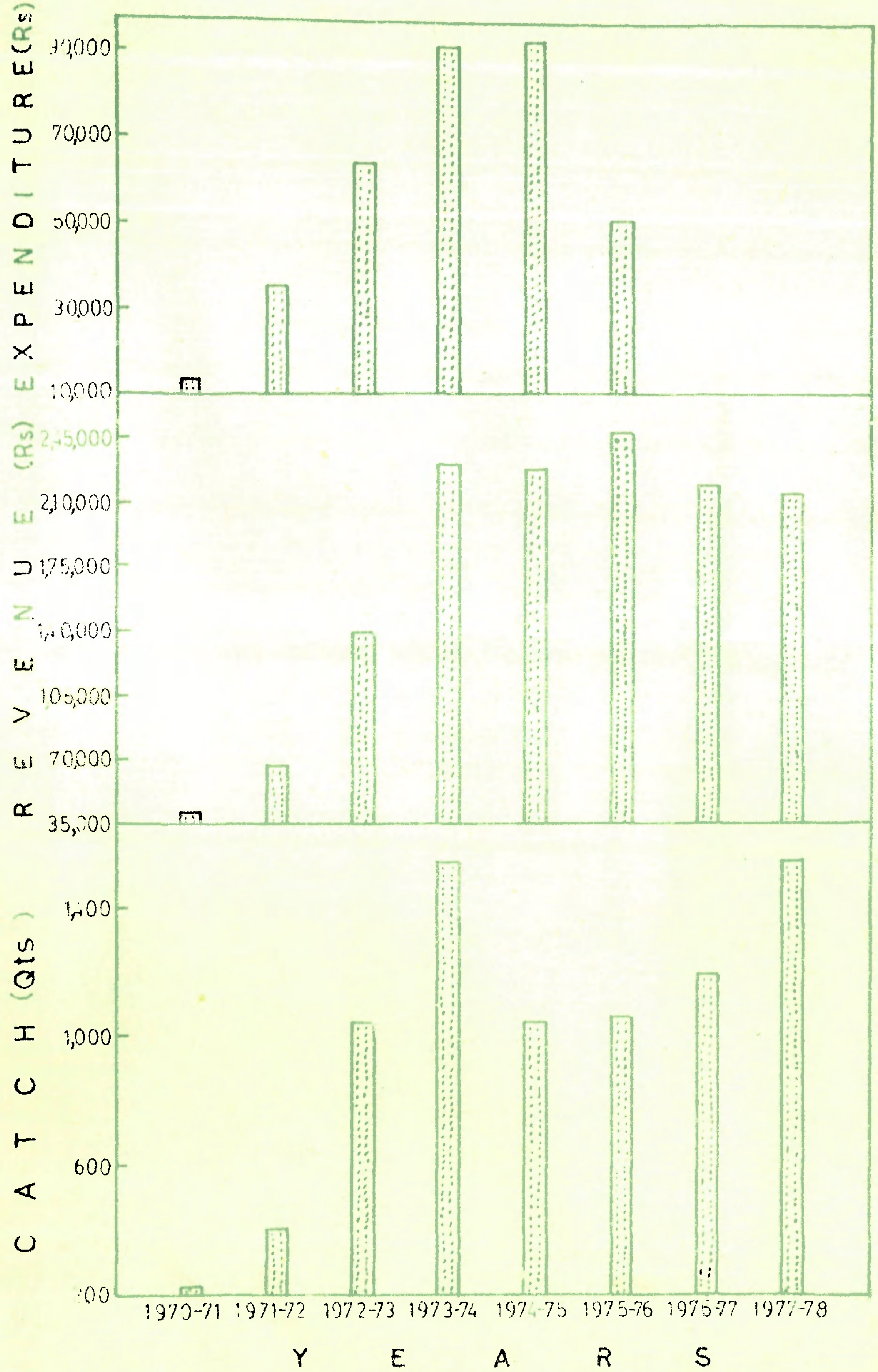
Months		Total No. of Samples	SIZE GROUPS				
			I (40 - 75 mm)	II (76–110 mm)	III (111–145 mm)	IV (146–180 mm)	V (181–215 mm)
			Frequency of occurrence				
		2154	258	671	600	465	160
October	1977	215 (10.0%)	37 (14.3%)	68 (10.1%)	41 (6.8%)	53 (11.4%)	16 (10.0%)
November	"	264 (12.3%)	38 (14.7%)	86 (12.8%)	70 (11.7%)	52 (11.2%)	18 (11.2%)
December	"	240 (11.1%)	30 (11.6%)	85 (12.7%)	66 (11.0%)	43 (9.2%)	16 (10.0%)
January	1978	200 (9.3%)	25 (9.7%)	57 (8.5%)	67 (11.1%)	38 (8.2%)	13 (8.1%)
February	"	254 (11.8%)	26 (10.1%)	77 (11.5%)	74 (12.3%)	52 (11.2%)	25 (15.6%)
March	"	275 (12.8%)	30 (11.6%)	88 (13.1%)	64 (10.7%)	71 (15.2%)	22 (13.7%)
April	"	238 (11.0%)	25 (9.7%)	62 (9.2%)	82 (13.7%)	52 (11.2%)	17 (10.6%)
May	"	220 (10.2%)	22 (8.5%)	78 (11.6%)	56 (9.3%)	51 (11.0%)	13 (8.1%)
June	"	248 (11.5%)	25 (9.7%)	70 (10.4%)	80 (13.3%)	53 (11.4%)	20 (12.5%)

TABLE VII

Monthly fluctuation in the harvest of *U. chagra* and its proportion in the total catch

Months	Year	Average landings (kg)	Percentage (%)	Year	Average landings (kg)	Percentage (%)
October	1977	2833.0	4.7	1976	2447.5	5.2
November	"	6811.5	11.3	"	5554.0	11.8
December	"	8499.0	14.1	"	8330.5	17.7
January	1978	10126.5	16.8	1977	6966.0	14.8
February	"	6269.0	10.4	"	5836.0	12.4
March	"	7776.0	12.9	"	6260.0	13.3
April	"	5244.0	8.7	"	3671.0	7.8
May	"	4581.0	7.6	"	2118.0	4.5
June	"	8137.5	13.5	"	5883.5	12.5
Total		60277.5			47066.5	

Fig. 1. Yearwise total fish catch, revenue and expenditure.



EXPENDITURE (Rs)
90,000
70,000
50,000
30,000
10,000
REVENUE (Rs)
2,45,000
2,10,000
1,75,000
1,40,000
1,05,000
70,000
35,000
CATCH (Qts)
1,400
1,000
600
200
1970-71
1971-72
1972-73
1973-74
1974-75
1975-76
1976-77
1977-78
YEARS

Fig. 2. Monthly total fish catch and revenue.

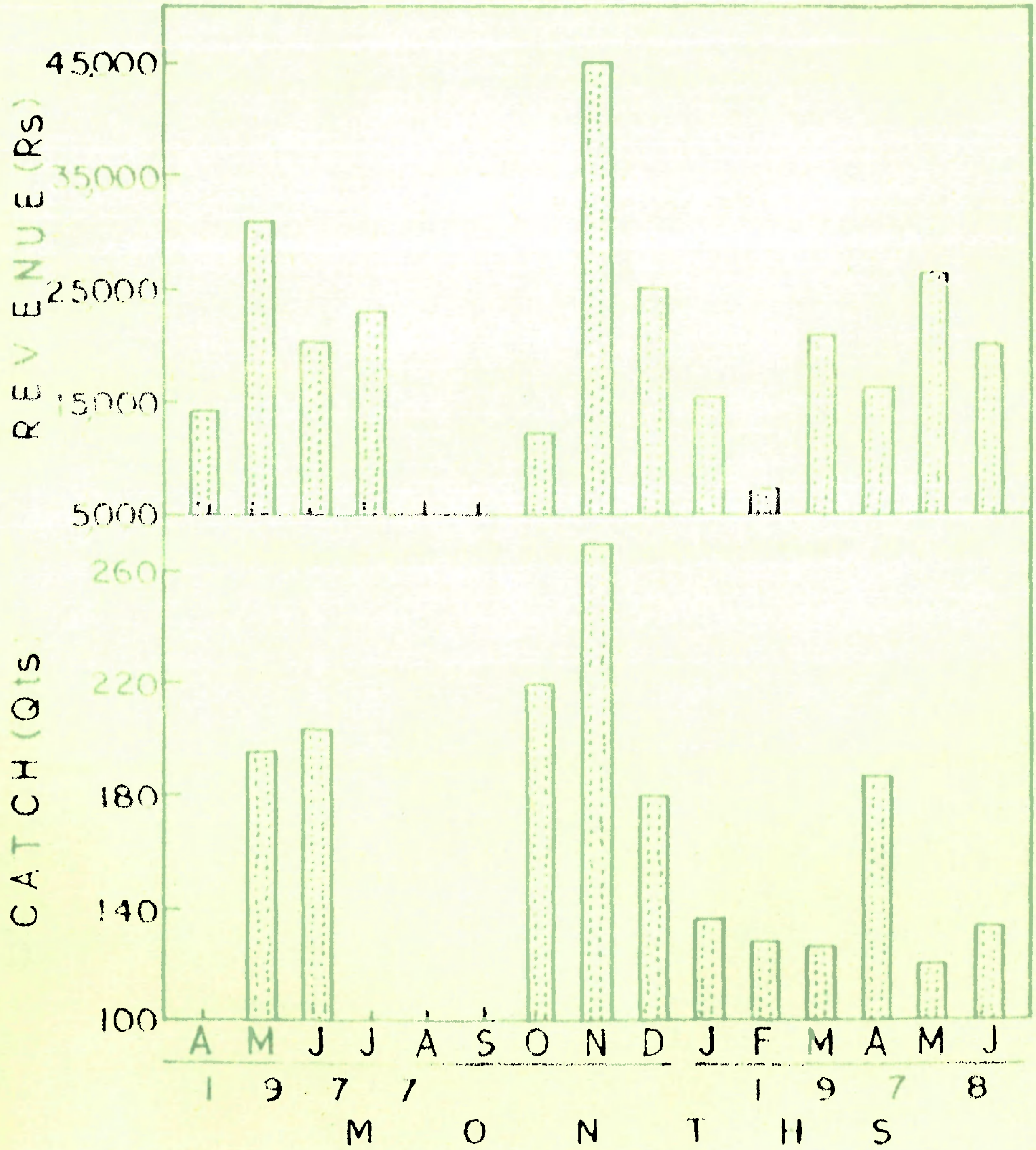
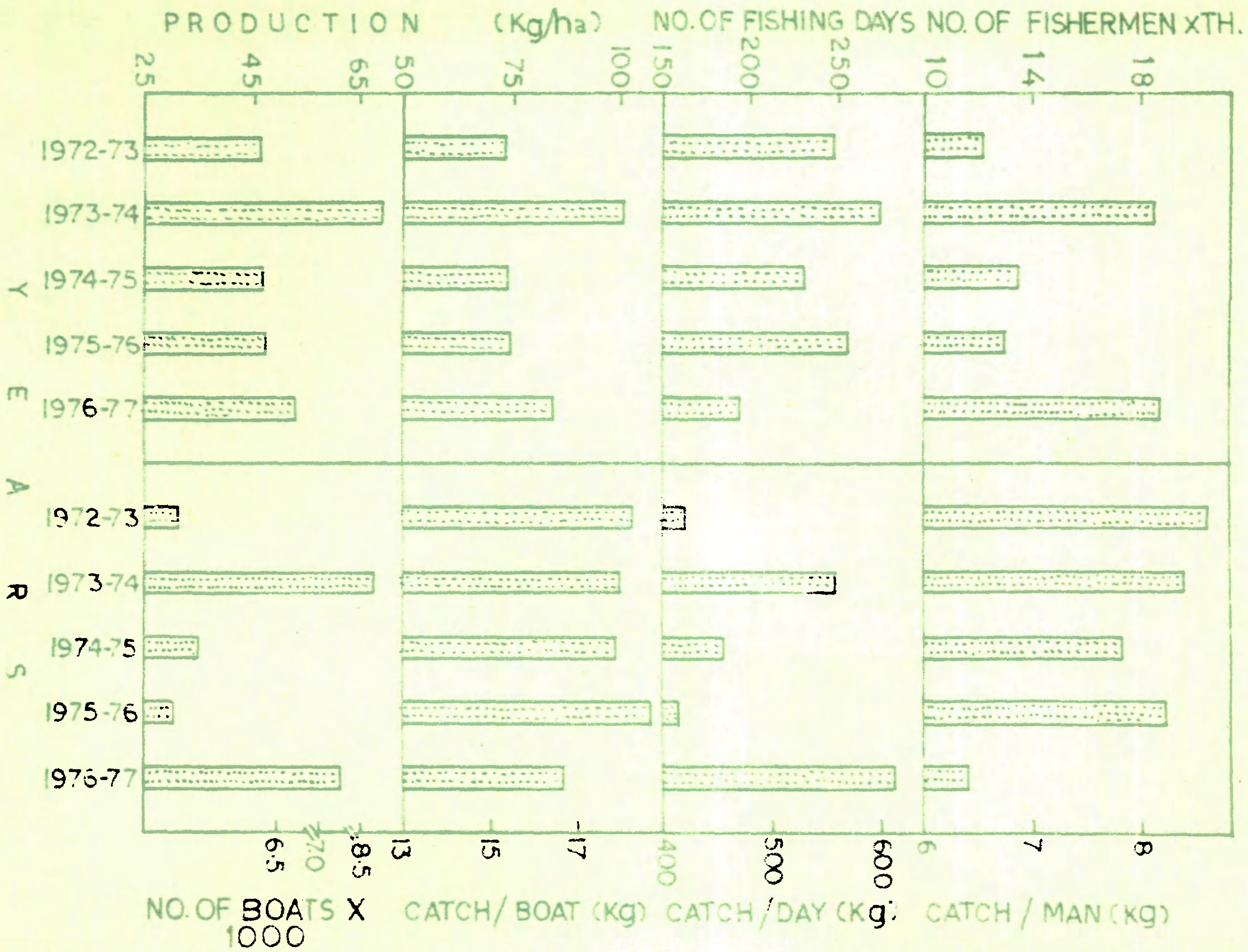
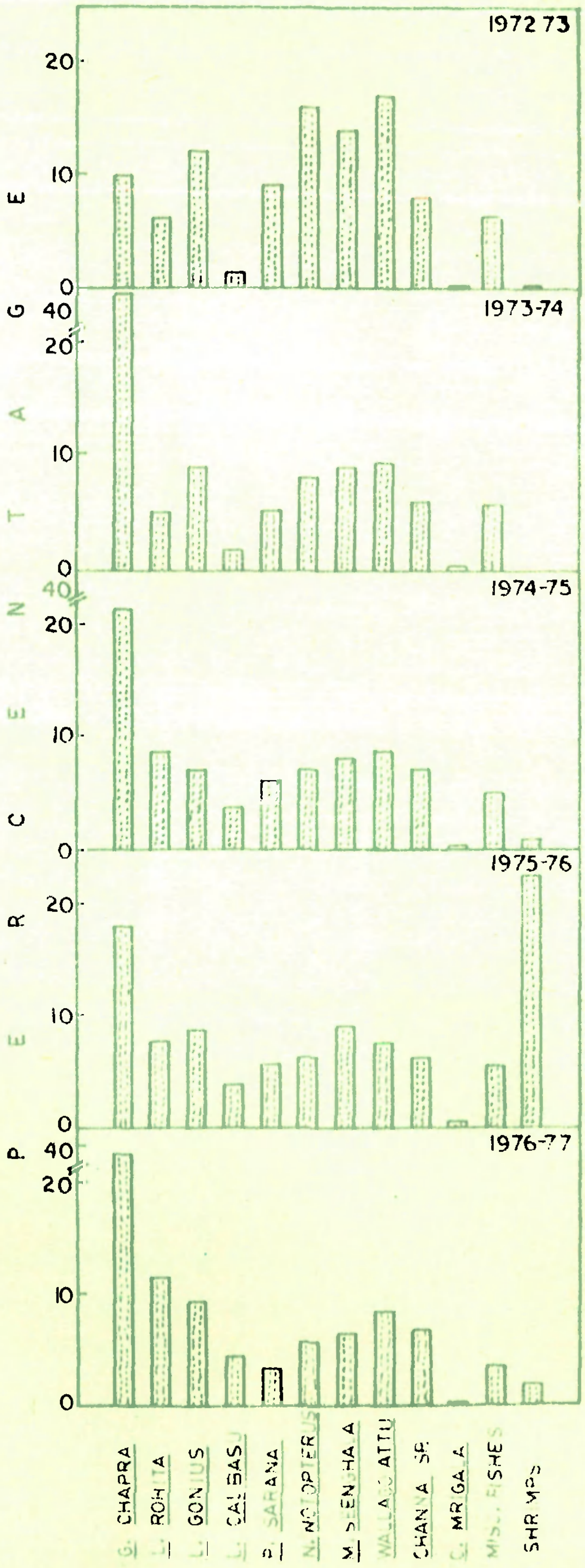

REVENUE (Rs)
45,000
35,000
25000
15000
5000
CATCH (Qls
260
220
180
140
100
A M J J A S O N D J F M A M J
1977
1978
MONTHS

Fig. 3. Yearly fish production and catch-effort data.



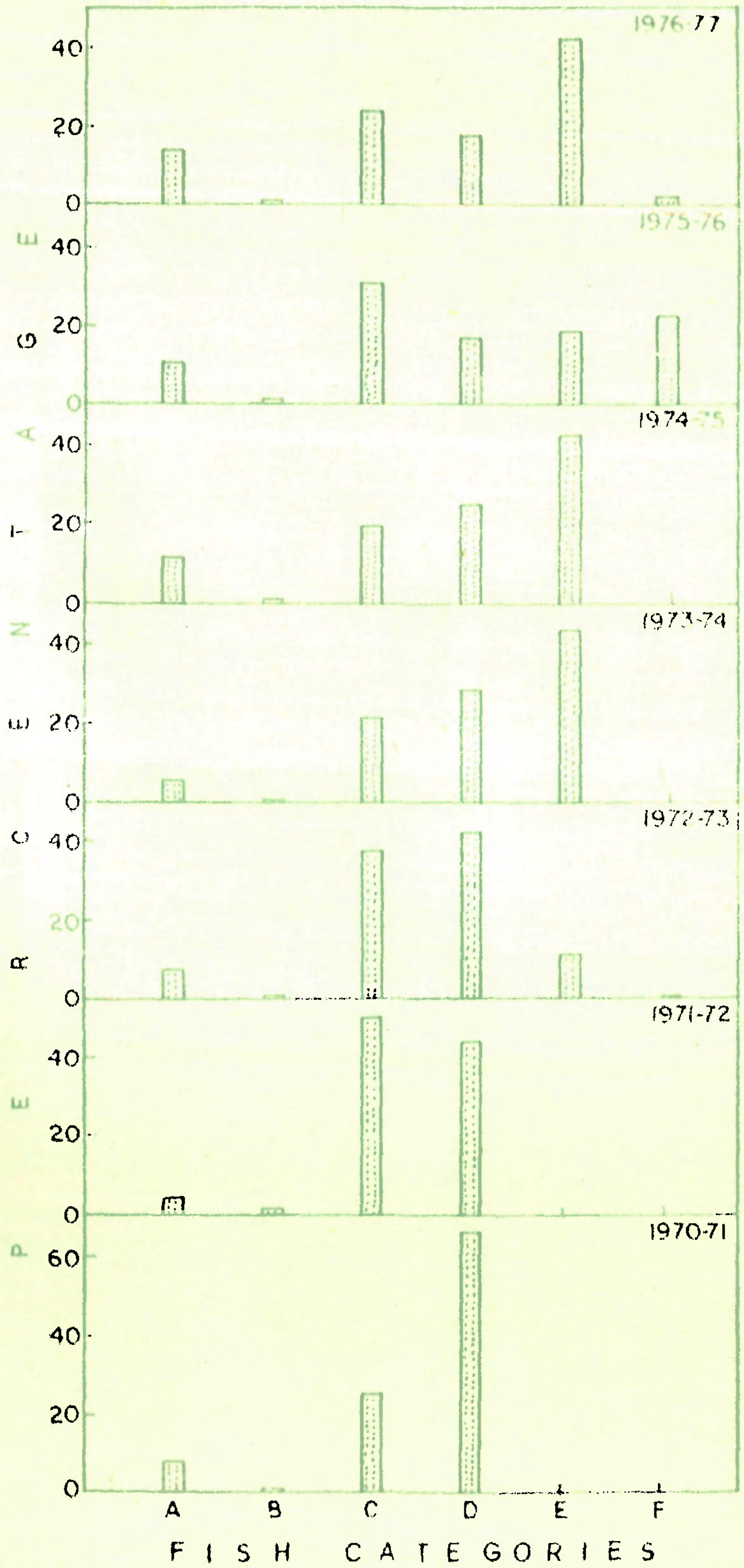
PRODUCTION (Kg/ha)
NO. OF FISHING DAYS
NO. OF FISHERMEN x TH.
YEARS
1972-73
1973-74
1974-75
1975-76
1976-77
NO. OF BOATS X 1000
CATCH/ BOAT (Kg)
CATCH / DAY (Kg)
CATCH / MAN (kg)

Fig. 4. Yearwise species composition of catch.



PERCENTAGE
1972-73
1973-74
1974-75
1975-76
1976-77
G. CHAPRA
L. ROHITA
L. GONIUS
L. CALBASU
P. SARANA
N. NOTOPTERUS
M. SEENGHALA
WALLAGO ATTU
CHANNA SP.
C. MRIGALA
MISC. FISHES
SHRIMPS

Fig. 5. Categorywise composition of catch in different years.



1976-77
1975-76
1974-75
1973-74
1972-73
1971-72
1970-71
PERCENTAGE
0
20
40
60
A
B
C
D
E
F
FISH CATEGORIES

Fig. 6. Percentage composition of the size-groups in the monthly catch.

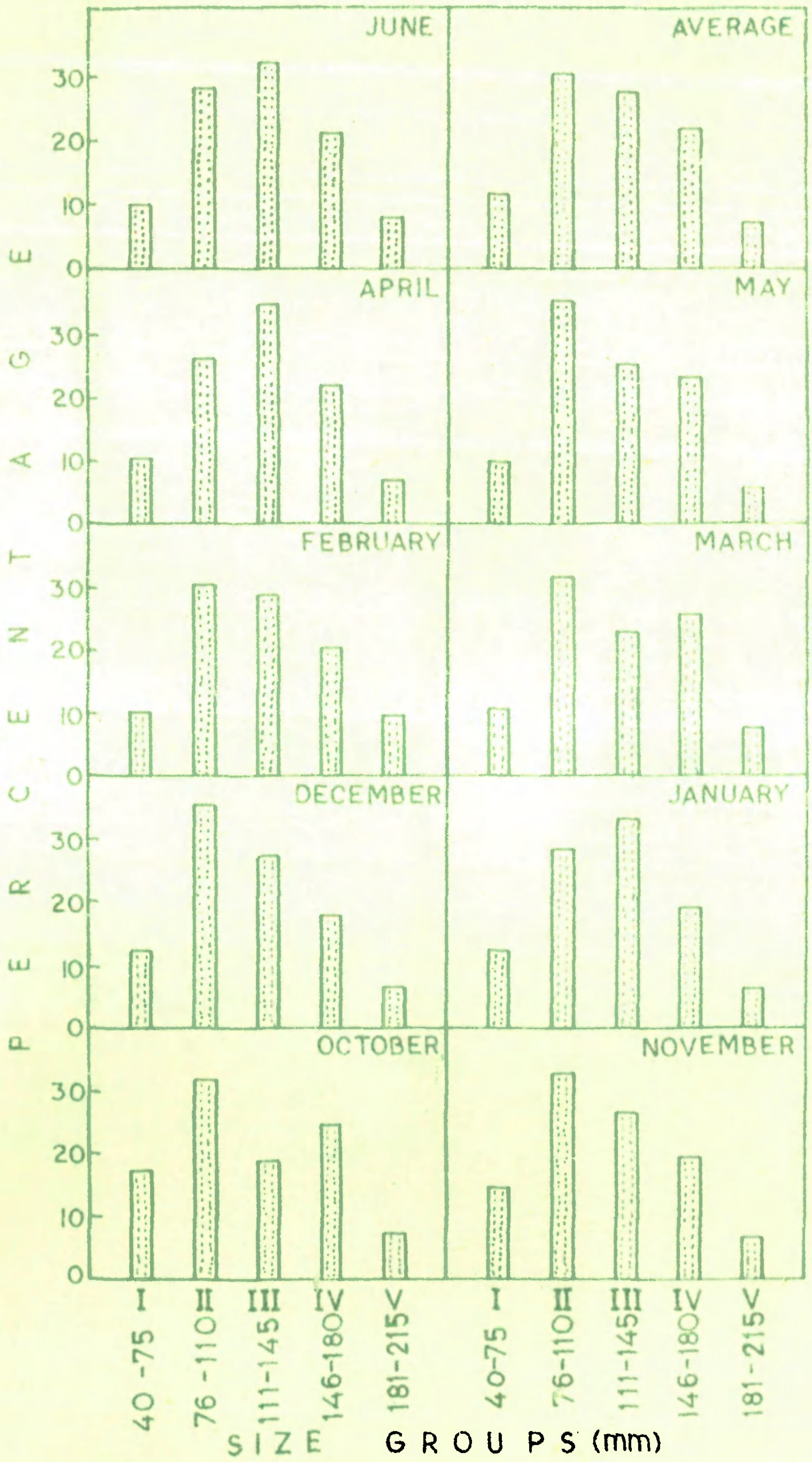
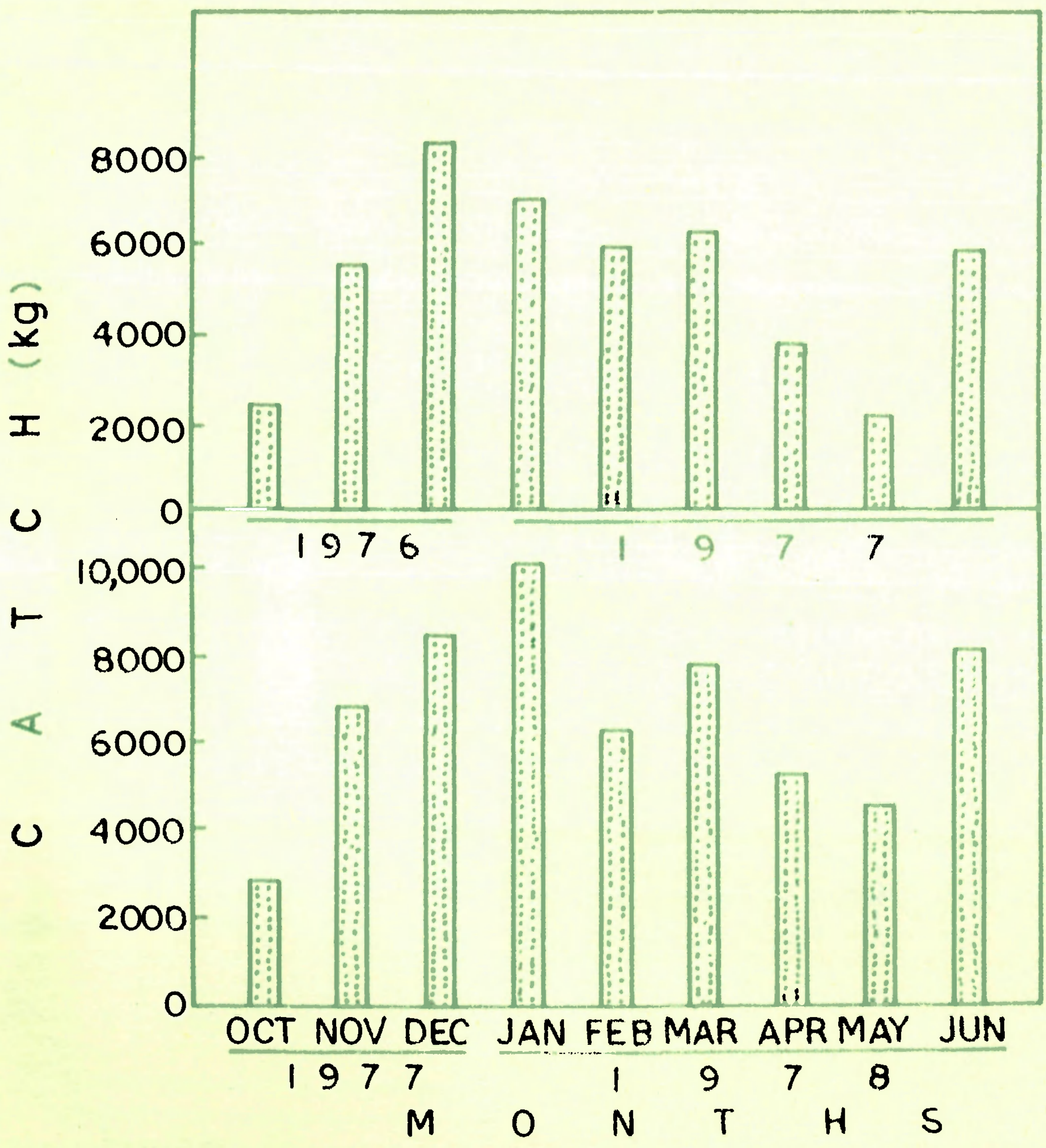

JUNE
AVERAGE
APRIL
MAY
FEBRUARY
MARCH
DECEMBER
JANUARY
OCTOBER
NOVEMBER
PERCENTAGE
0
10
20
30
I
II
III
IV
V
40-75
76-110
111-145
146-180
181-215
SIZE GROUPS (mm)

Fig. 7. Monthly catch of *C. chanos*.


CATCH (kg)
8000
6000
4000
2000
0
1976
1977
10,000
8000
6000
4000
2000
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978
MONTHS

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